Disruptive Technology: An Uncertain Future

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Defense Research and Engineering

Future Battlespace

"Innovation within the armed forces will rest on experimentation with new approaches to warfare, strengthening joint operations, exploiting U.S. intelligence advantages, and taking full advantage of science and technology….."

Definition of Disruptive Technology

The Textbook Definition

- **Harvard Professor, Clayton Christensen* described disruptive technologies as a lower-performance (but cheaper) new product that can be improved more rapidly, so that performance outpaces the product it is replacing**

- **Key concepts:**
  - **Greater performance than previous product**
  - **Replaces (drives) old product out of market**

**** "The Innovator's Dilemma", 1997***

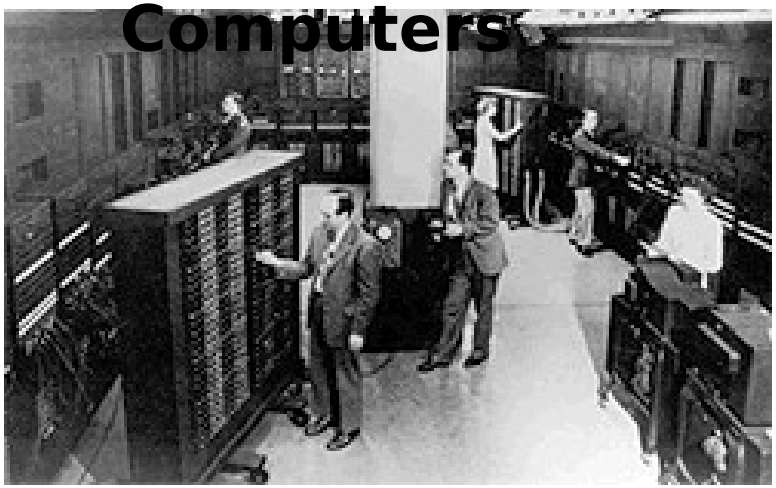
Disruptive Technology
The Non-Textbook Definition

- **For Defense systems, lower cost and lower initial performance does not matter**
- **What matters is rapid evolution from old, stable technology to new, dominating technology**
- **A technology surprise that gives a competitor an advantage**
  - **Business - Technology that overturns market**
  - **Military - Technology that causes a fundamental change in force structure, basing, and capability balance**
- **Disruptive Technologies may arise from systems or enabling technology**

Definition of Disruptive Technology

Some Historical Examples--Commercial

Candle	→	Electric Light
Vacuum Tubes	→	Transistors
Mechanical Watches	→	Quartz Watches
Mainframe Computers	→	Personal Computers



In each case, the disruptive technology decimated the conventional market - in a very short time

Definition of Disruptive Technology

Some Historical Examples--Military

Spotters	→	Radar
Bombers	→	ICBMs
Horse Drawn Artillery	→	Armored Howitzers
Flares	→	Night Vision

In Each Case, the Disruptive Technology Changed the Force Structure

A Focus on Revolutionary Advances

Stealth

Adaptive Optics and Lasers

GPS

Night Vision

Phased Array Radar

Definition of Disruptive Technology

Extended to the DoD

- **For Military Application, a Disruptive Technology may be offensive, defensive, or "spin-off"**
  - **Offensive - A capability developed to provide a "transformational" new capability**
  - **Defensive - A capability developed in response to someone else's advantage**
  - **Unintended - A capability developed for commercial….but with military applications**

Disruptive Technologies

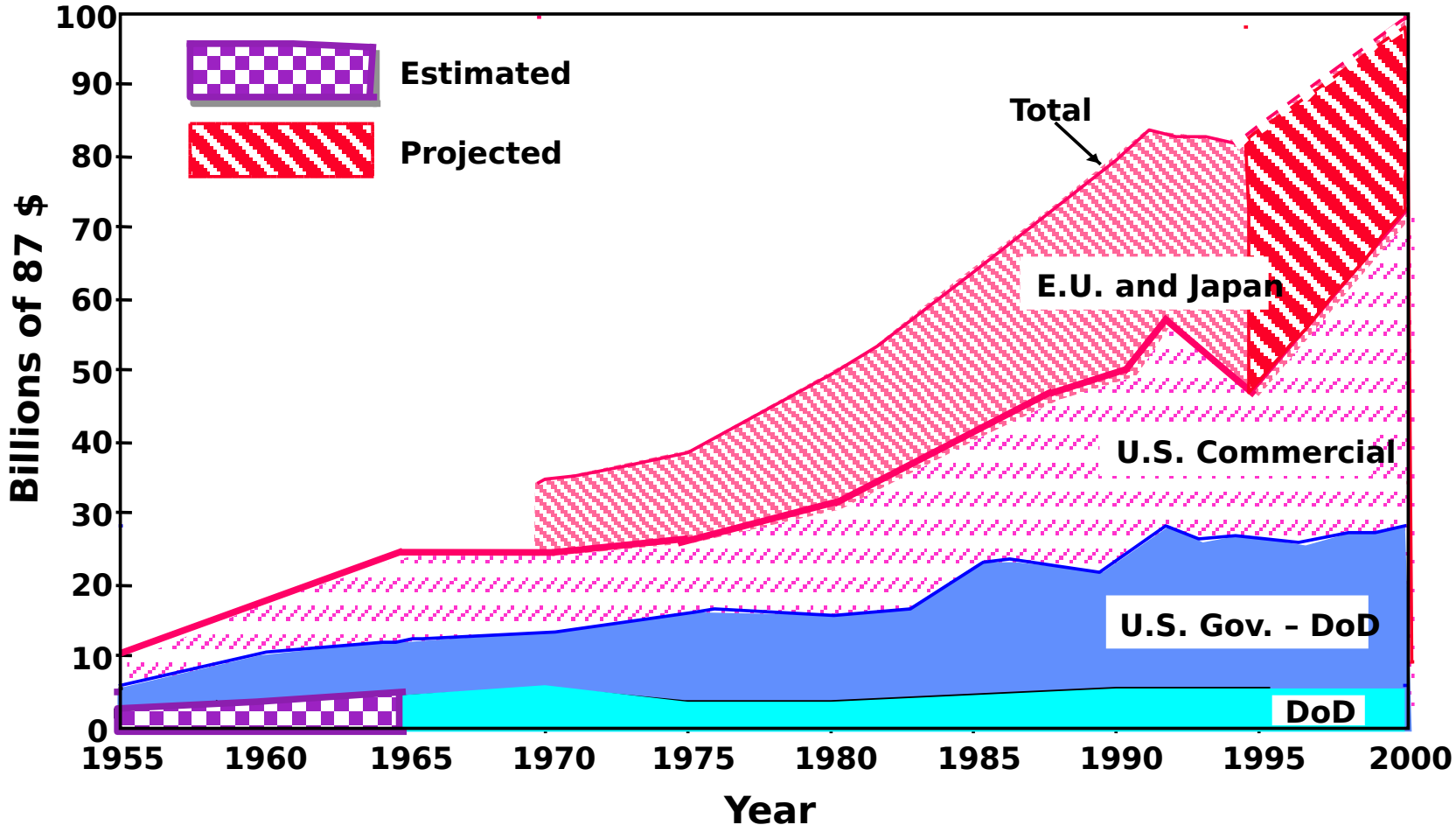
Frequently Take a Forcing Function

Technology	Approximate Date Lab Demo	Approximate Date of First Military Applications		Of First
Radio	1901	1914		
Airplane		1903	1916	
Vacuum Tube		1906	1915	World War I
Mechanized Tank			1916	1916
Liquid-Fueled Rockets		1922	1944	
Radar*	1925	1939		
Gas Turbine*		1935	1944	
Digital Computer*			1943	1945
Ballistic Missile*			1944	1945
Nuclear Weapons*			1945	1945
Transistor*		1948	1957	
Inertial Navigation*			1950	1955
Nuclear Propulsion*			1950	1954
Artificial Earth Satellites*			1957	1960
Integrated Circuit*			1960	1970
Laser*	1961	1967		
Precision Weapons*			1965	1967
AI Expert System*			1965	1990

World War II

Cold War

U.S. and Worldwide Research Base Since WWII



Source: Report of the Defense Science Board Task Force on the Technology Capabilities of Non-DoD Providers; June 2000; Data provided by the Organization for Economic Cooperation and Development & National Science Foundation

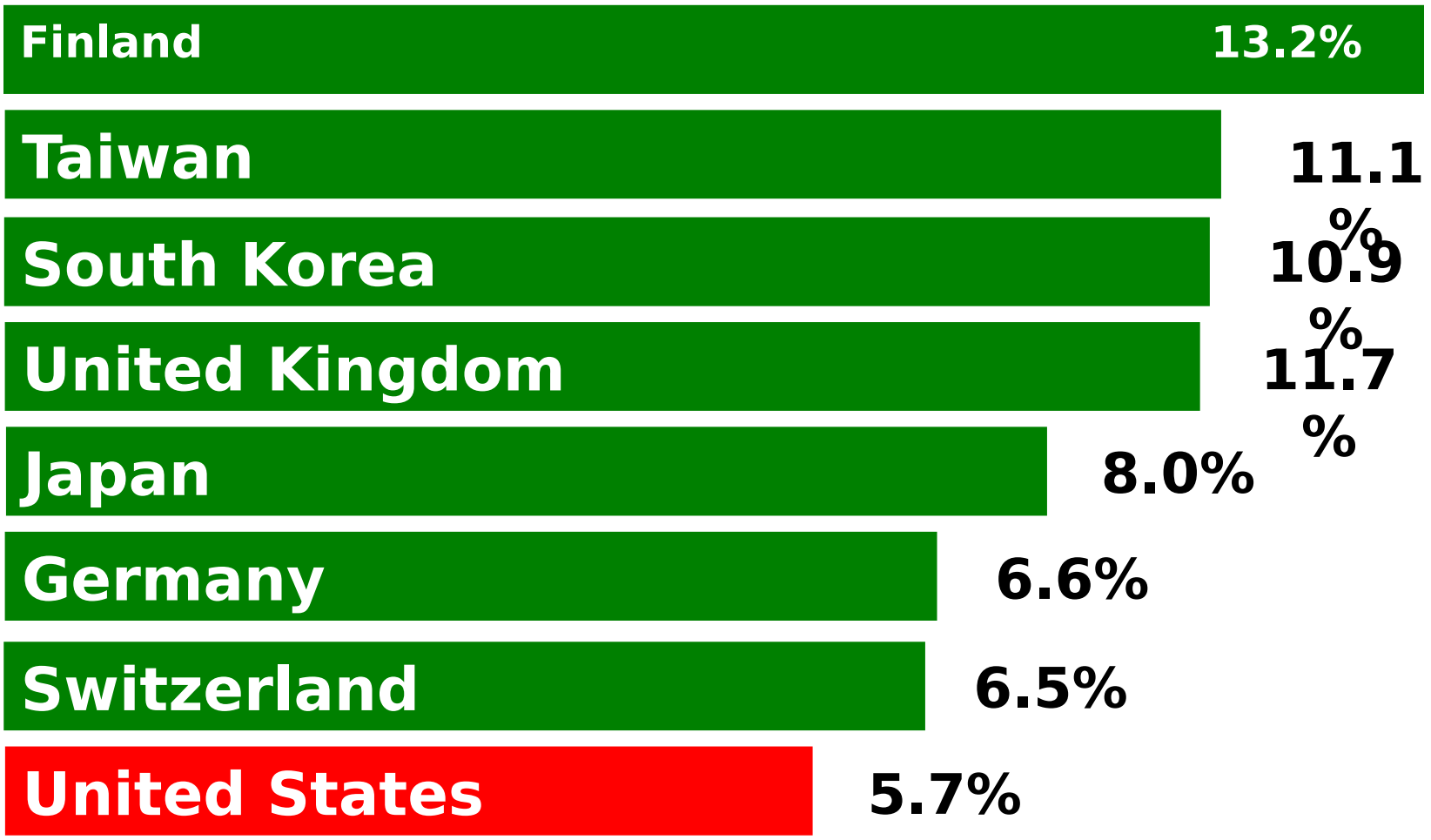
A National Issue

- "An Emerging and Critical Problem of the Science and Engineering Workforce"[1]
  - 12 Major studies (1999-2004) make essentially the same point
  - A few studies did not consider security clearance needs and rely on relaxation of immigration rules

- Growing need for U.S. citizens in national security activities

1. National Science Board Companion Paper to "National Science and Engineering Indicators 2004", National Science Foundation, April 2004

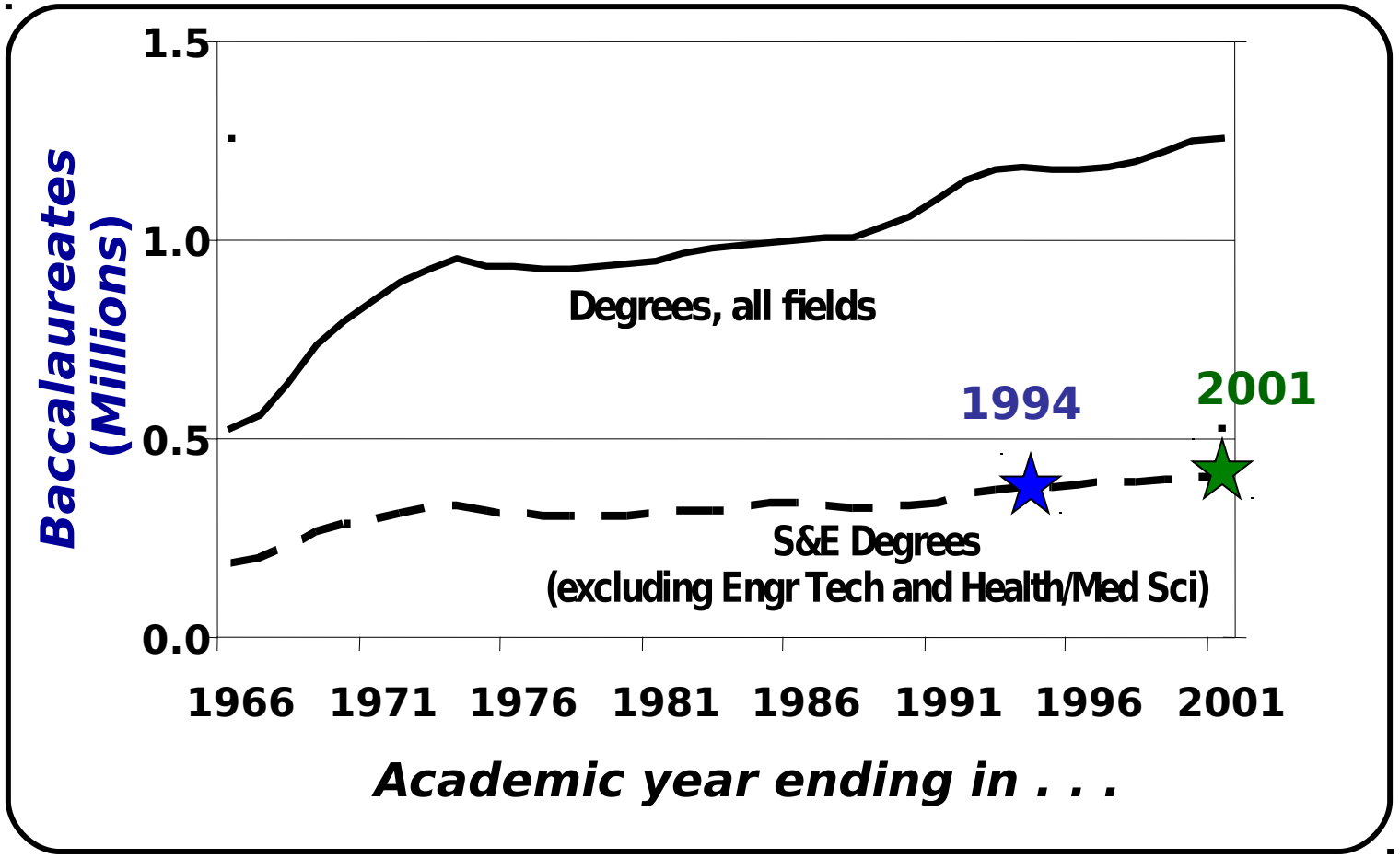
Percentage of 24-year-olds with a Science or Engineering Degree



Source: Money Magazine, Oct 2004, pg 124

.S. Production of S&E Graduates*

U.S. College and University Graduates, 1966-2001



Source: Data provided by the NSF, September 2003

U.S. University Trends in Defense-Related S&E *Graduate Student Enrollment (1994-2001)*

ce: National Science Foundation – Graduate Students and Post Doctorates in Science and Engineering: Fall

Science Disciplines

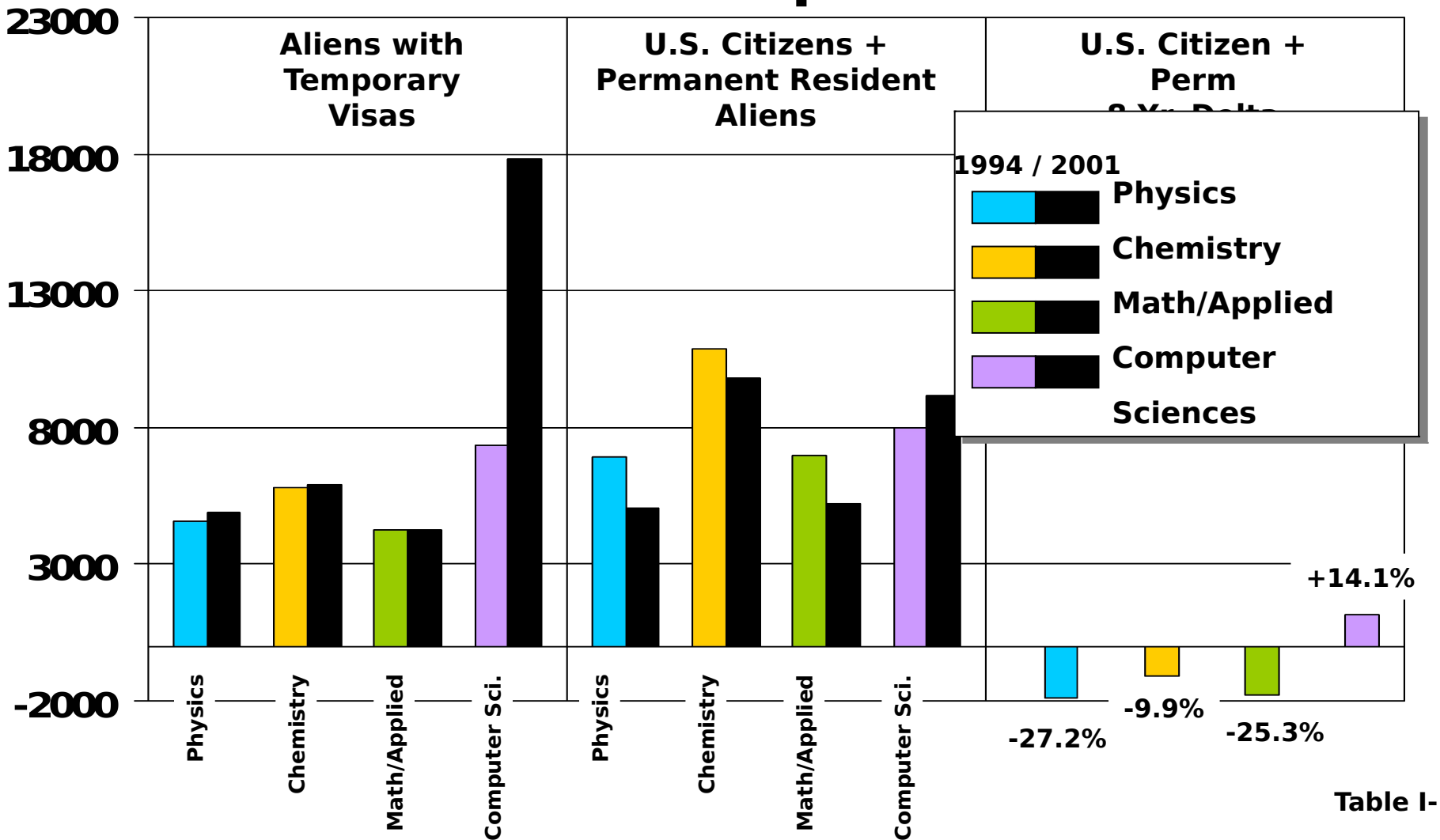
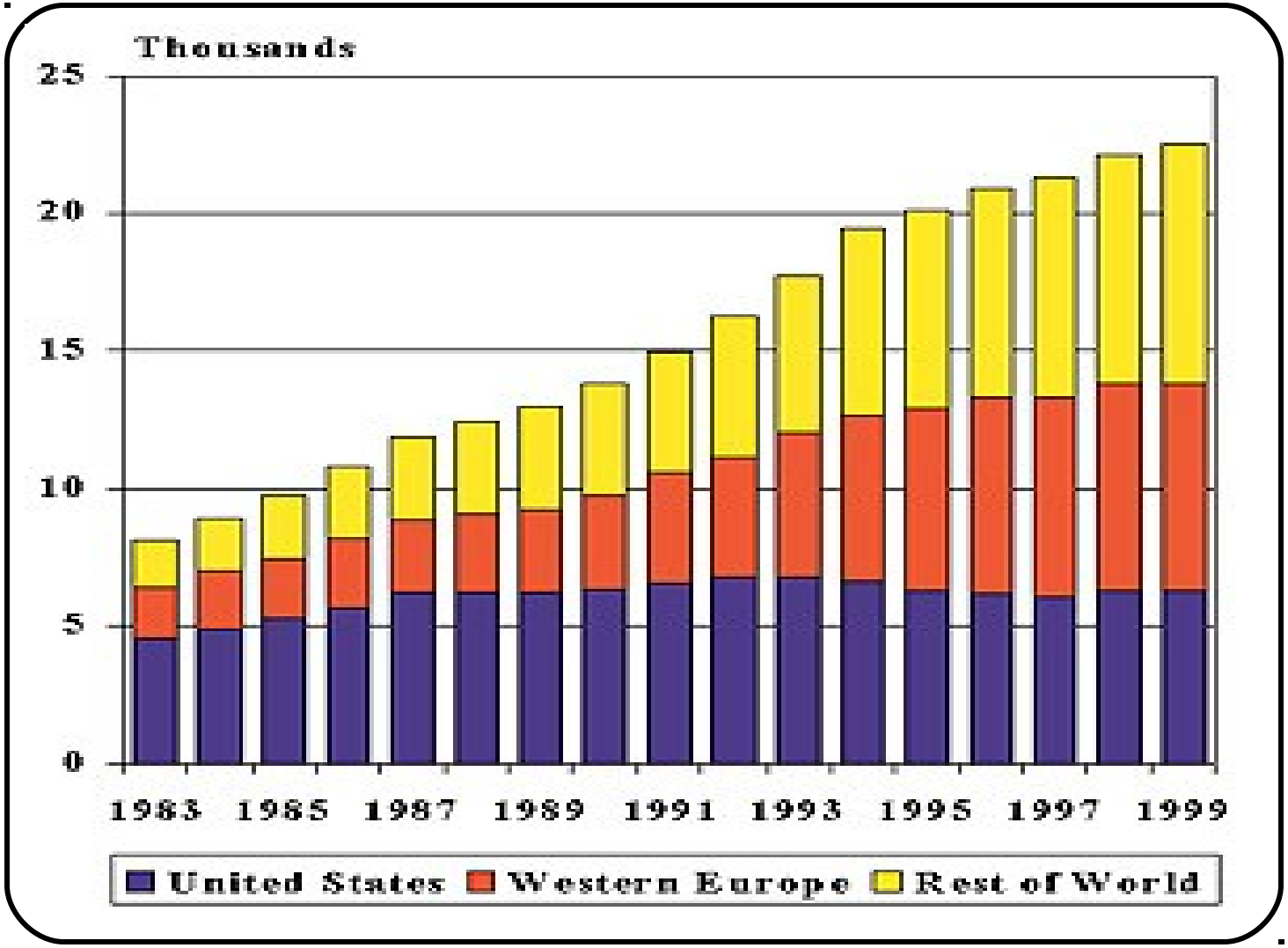


Table I-

Physical Review Trends

Physical Review & Physical Review Letters

Total Submissions



Source: American Physical Society - *APS News August/September 2000*

Security Environment: 4 Challenges

Irregular

- Unconventional methods adopted by non-state and state actors to counter stronger state opponents.
- (e.g., terrorism, insurgency, civil war, and emerging concepts like “unrestricted warfare”)

Catastrophic

- Surreptitious acquisition, possession, and possible employment of WMD or methods producing WMD-like effects against vulnerable, high-profile targets by terrorists and rogue states. *(paralyze our power)*
- (e.g., homeland missile attack, proliferation from a state to a non-state actor, devastating WMD attack on ally)

Traditional

- Military capabilities and military forces in long-established, well-known forms of military competition and conflict.
- (e.g., conventional air, sea, land forces, and nuclear forces of established nuclear powers)

Disruptive

- International competitors developing and possessing breakthrough technological capabilities intended to supplant U.S. advantages in particular operational domains. *(marginalize our power)*
- (e.g., sensors, information, bio or cyber war, ultra miniaturization, space, directed-energy, etc)

VULNERABILITY

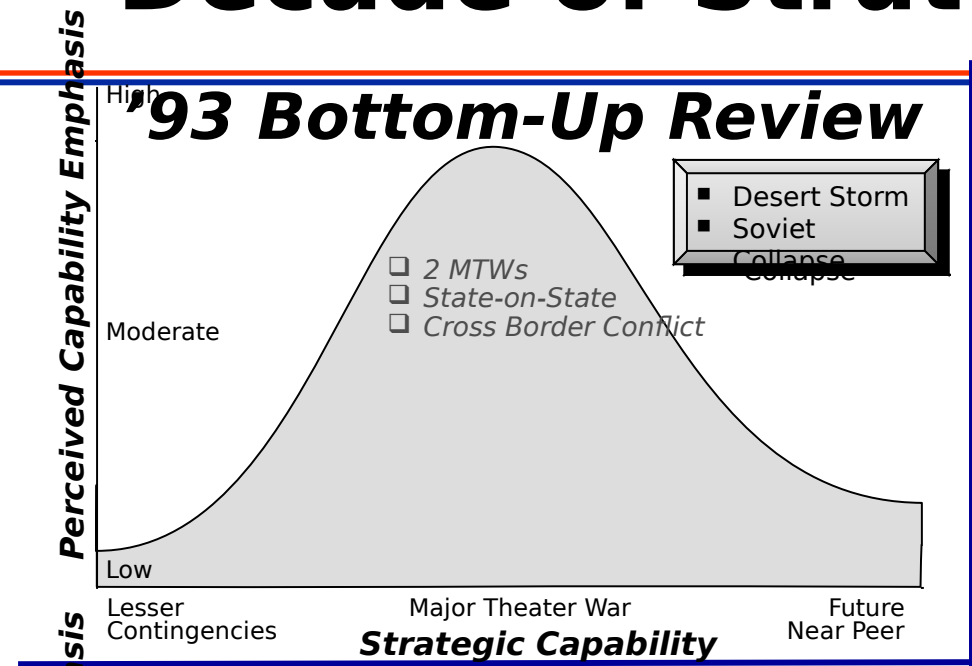
Lower — Higher

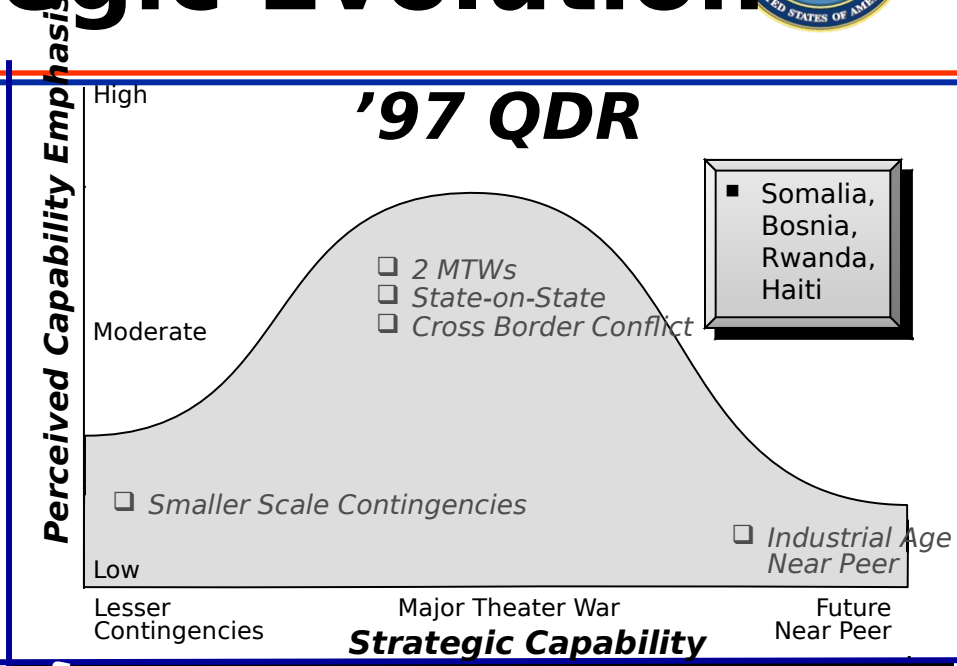
LIKELIHOOD

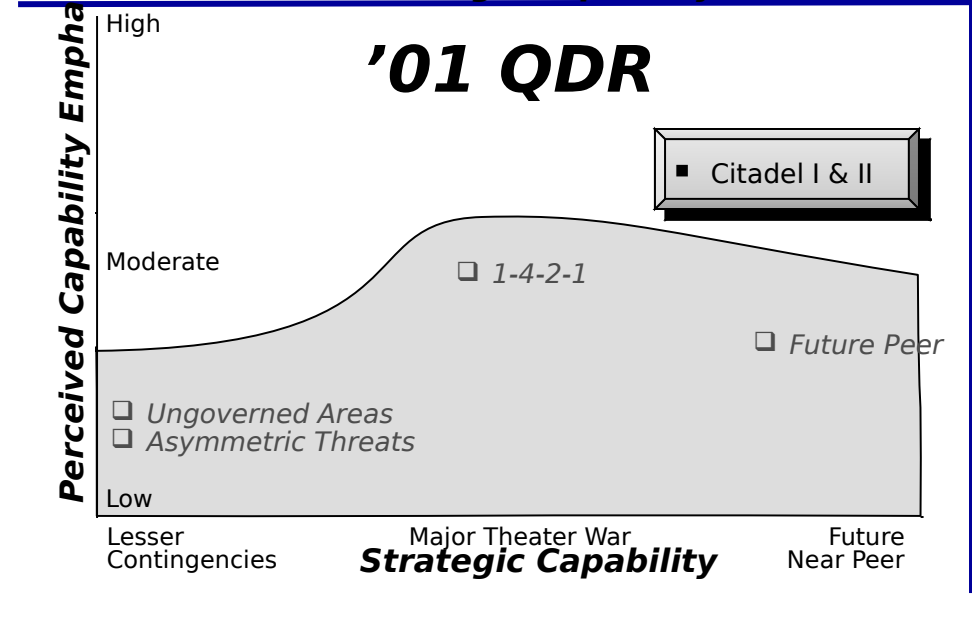
Higher — Lower

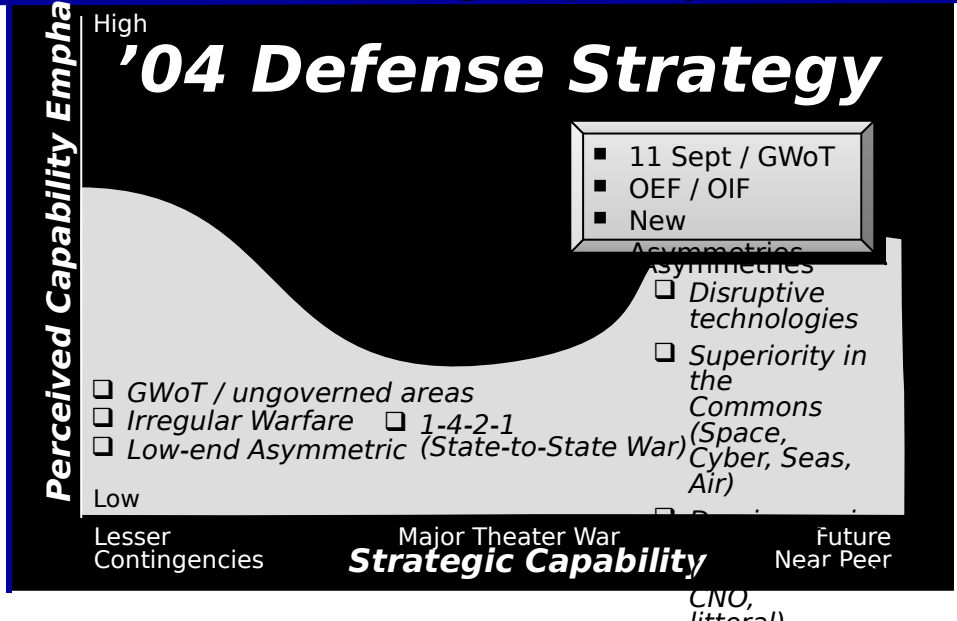
Capabilities-based planning should balance risk across challenges

Decade of Strategic Evolution







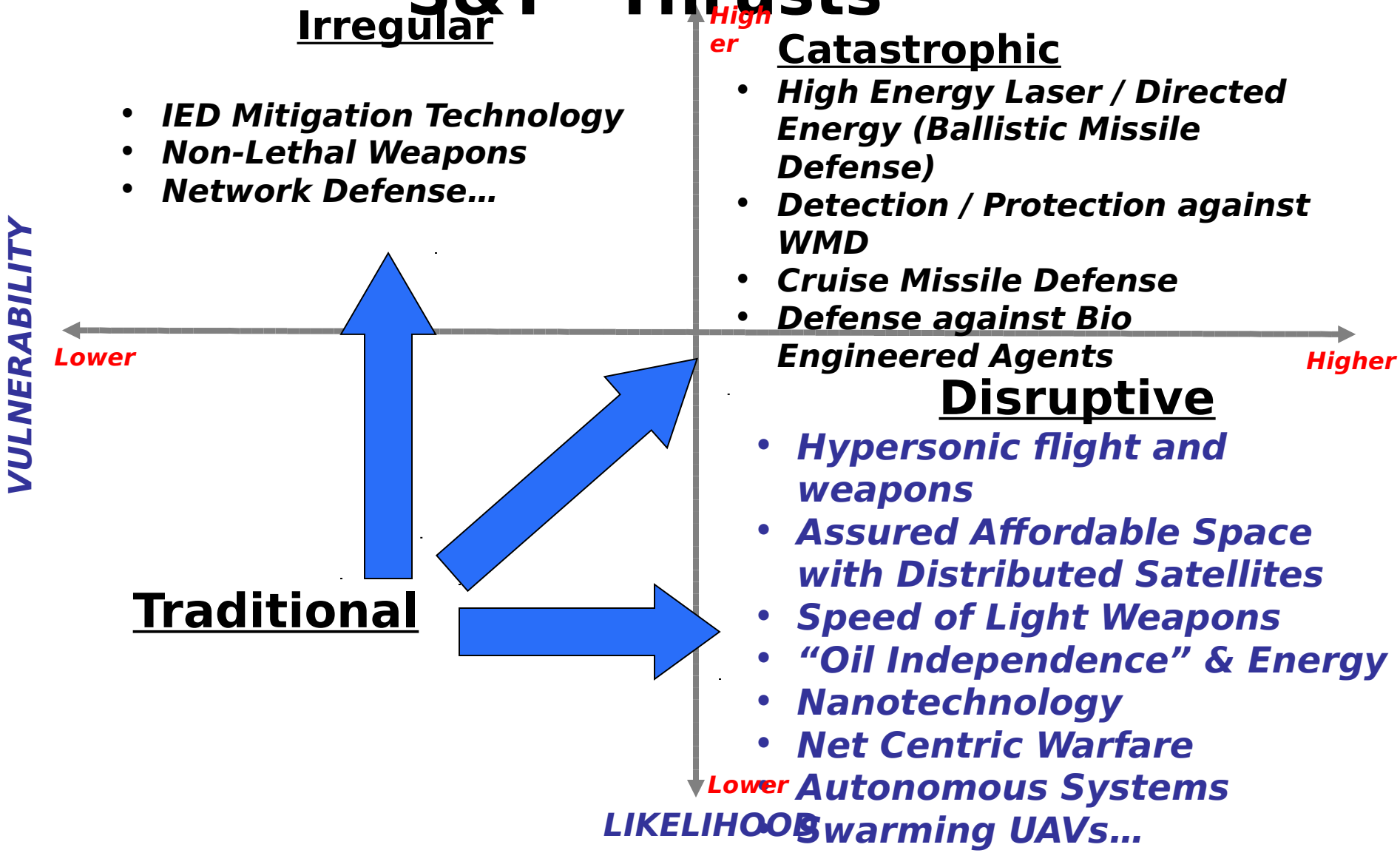


Disruptive Technology Dimensions
Attributes

- **Transformation Occurs With Leaps In Capabilities:**
  - **Manhattan Project—Lethality**
  - **Reconnaissance Satellites—Knowledge**
  - **Stealth—Agility**

Offensive Disruptive Technology is Transformational

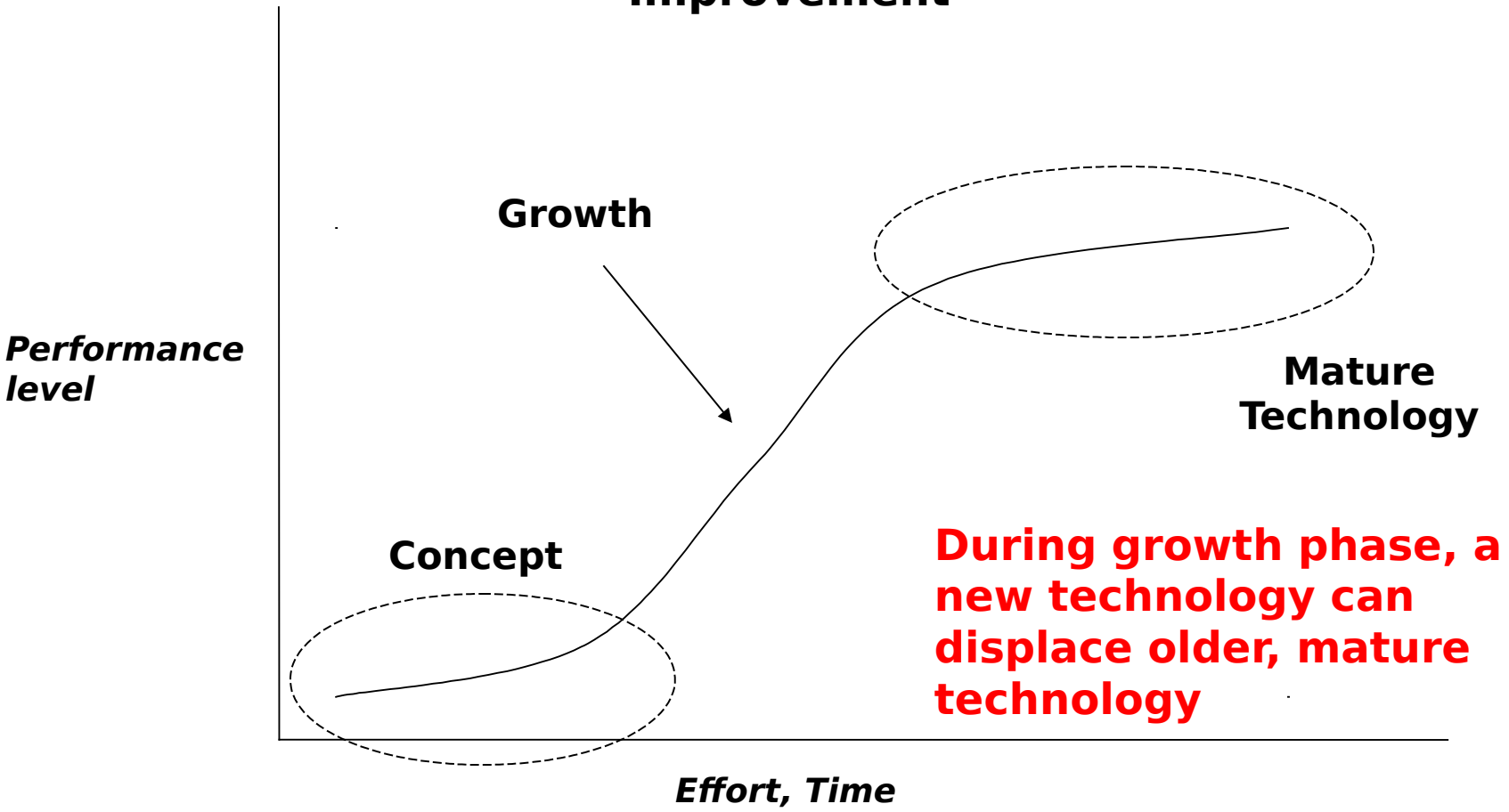
Security Environment: Strategy S&T "Thrusts"



A Final Concept
Technology S-Curve

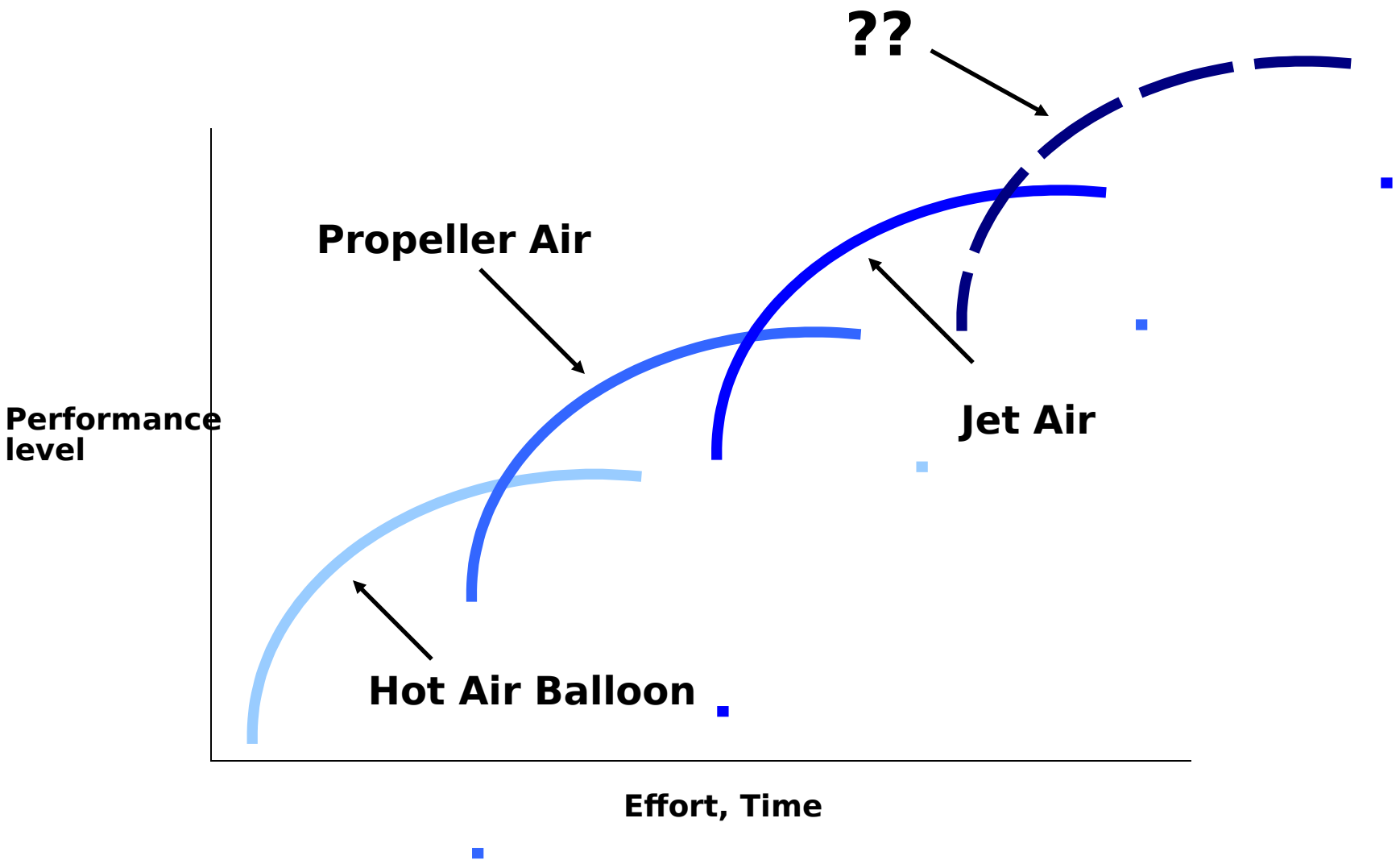
Most Technology maturation follows S-curve:

Initial Discovery, "Product-ization", then Incremental Improvement



Family of S-Curves

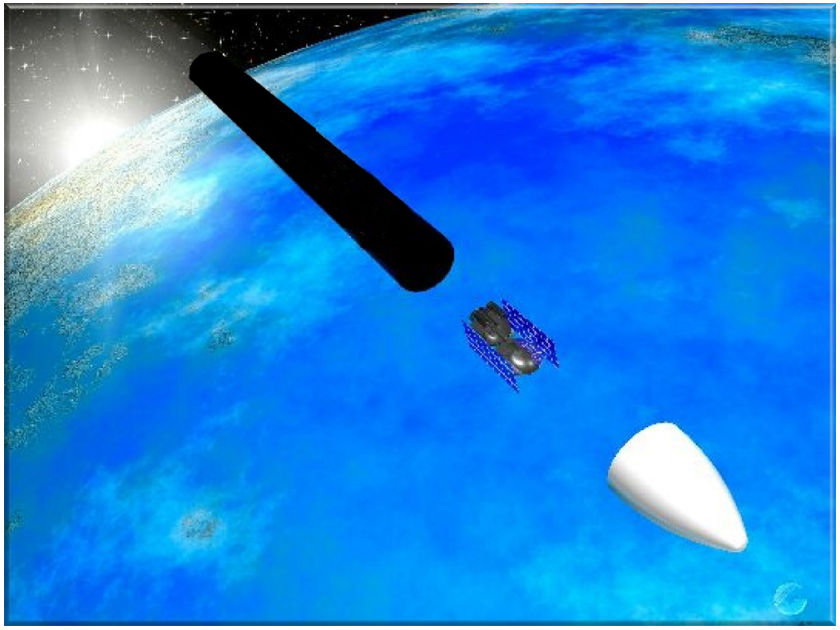
Military Aircraft



Falcon

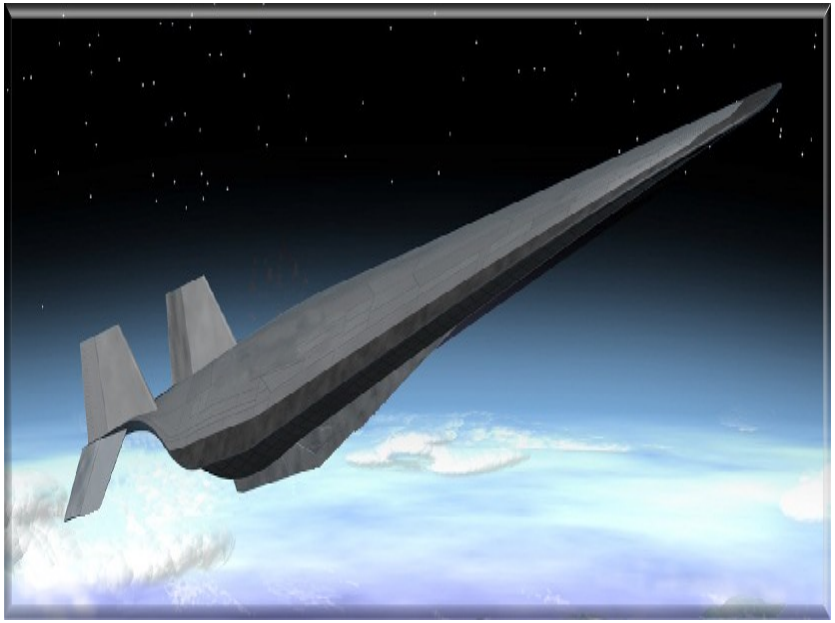
Near-Term Capability

Operationally Responsive Spacelift Capability



Far-Term Capability

Hypersonic Cruise Vehicle

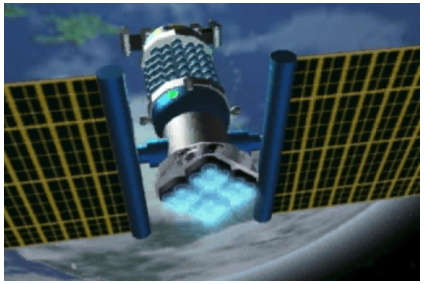


DARPA – Air Force Program

Propulsion Technology

Turbine Propulsion and Fuels Technology

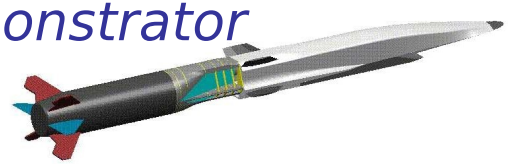
• Engine Component Development • Demonstrat
Engines • Fuels, Lubes, and Combustion



Rocket Propulsion Technology

• Rocket Engine and Fuel Technologies • Satellite Propulsion • Tactical and Ballistic Missile Propulsion

Advanced Propulsion Technology - *• Hypersonic Flight (Mach 4-8) Components • Scramjet Demonstrator Engines*

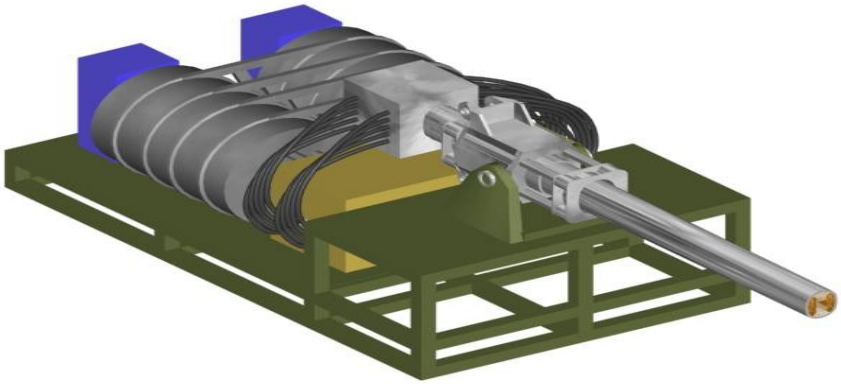


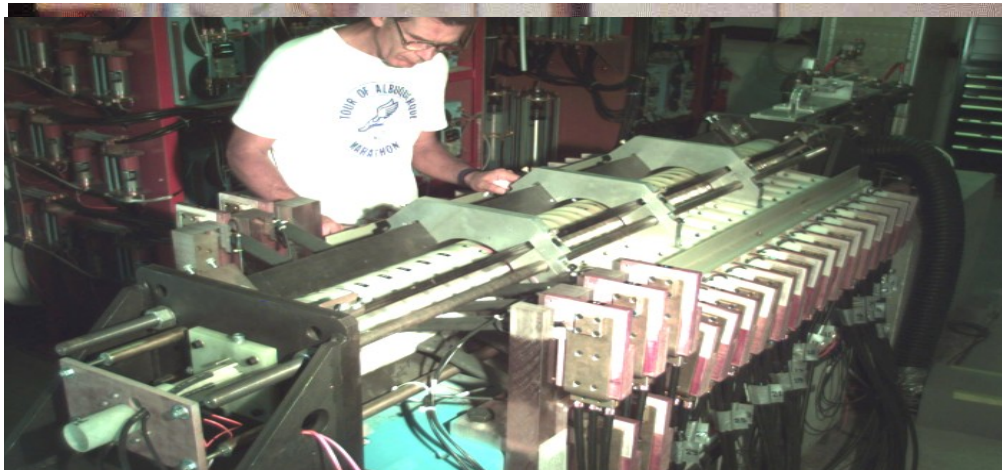
Fuels

Aircraft and Weapon Power -

• Electrical Power Generation and Thermal Management for Aircraft • High Power Generation and Storage for Space and Directed Energy

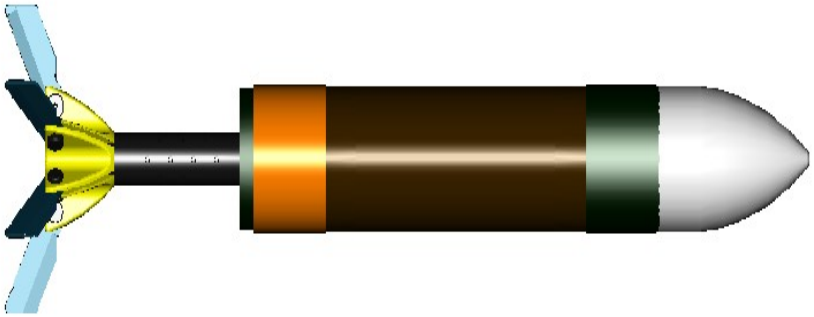
Electromagnetic Mortar (EM Mortar)



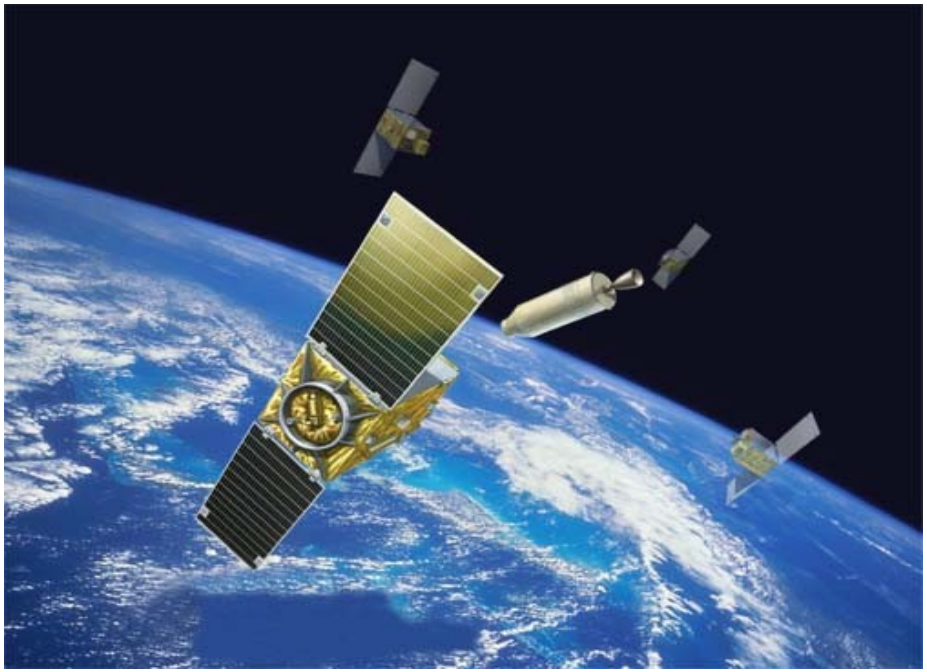


- Precision, lethality, fast response,

rapid strike, and versatility for artillery and sensor launch

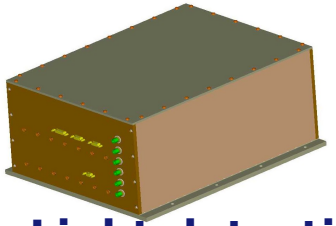


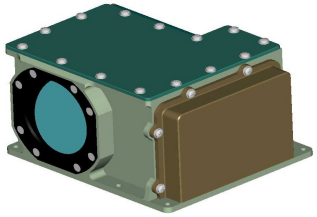
AF XSS-11



- **First demonstration of a fully autonomous satellite designed to demonstrate:**
  - **Software logic and algorithms to safely rendezvous and navigate around and inspect a resident space object**
  - **Mission planning, validation, verification tools, and operational tools and techniques**
  - **Collision avoidance—space situational awareness**

3u PCI Avionics

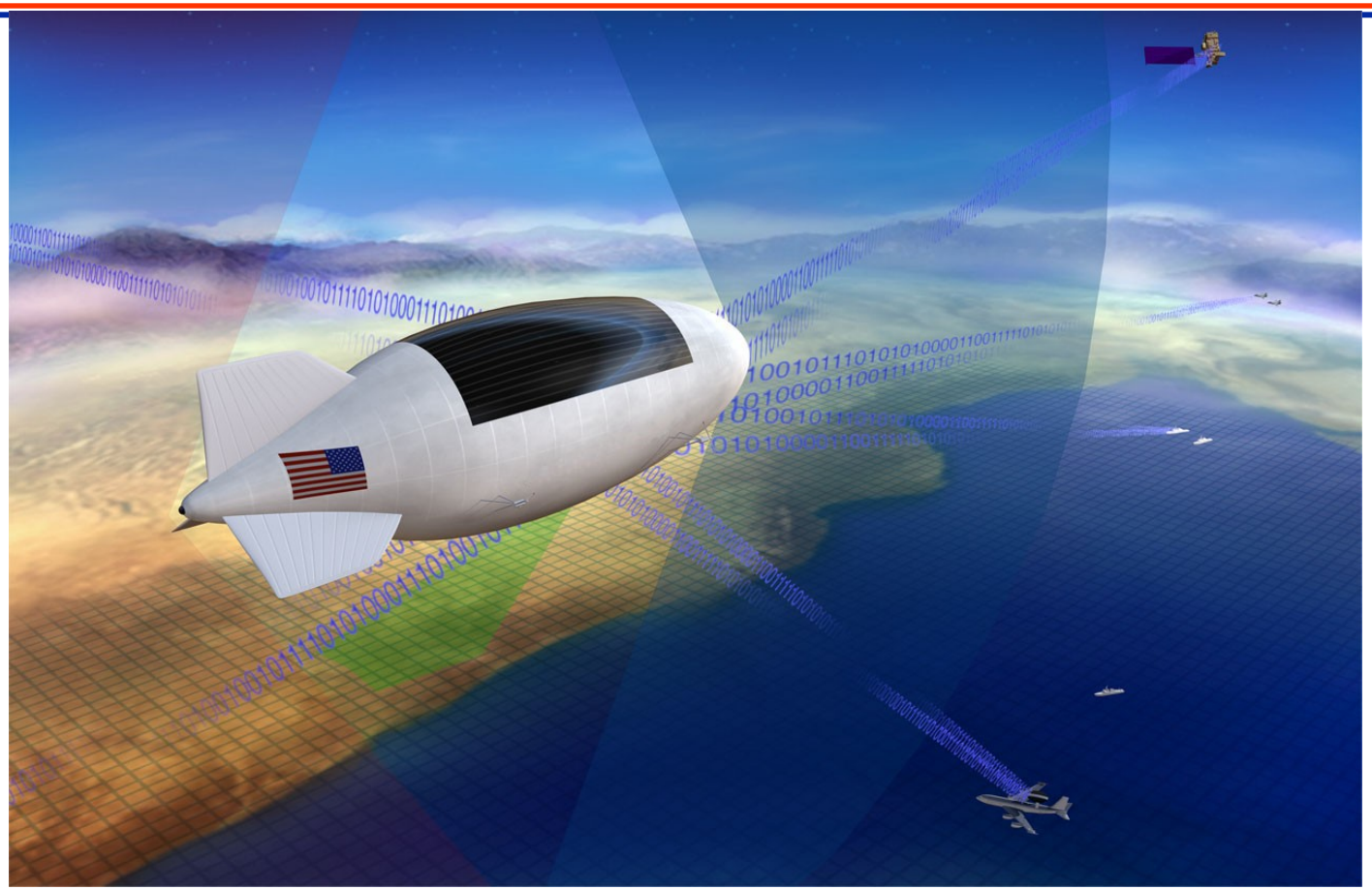




Light detection and ranging rendezvous system

Integrated imager and star camera

High Altitude Airship (HAA)

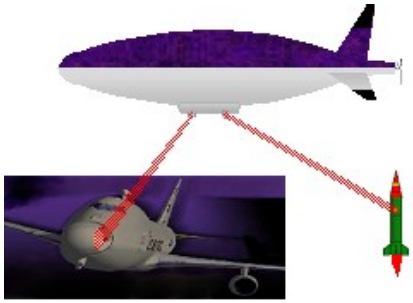


Transformational military capability; potential use as sensor, communications, and/or weapons platforms; demonstrator for future high altitude airships.

Directed Energy

Laser Devices and Analyses:

• Laser Devices - Photon Generators • Solid State and Chemical Lasers • Laser System Effects and Modeling



Laser Beam Control and Optics:

• Atmospheric Compensation/Beam Control Techniques to Get the Beam on Target to Do the Mission • Space Situational Awareness • Laser Communications

High Power Microwaves (HPM):

• Devices for Graduated Effects - Disrupt, Degrade, Damage, Destroy Electronics • Non-Lethal Long-Range Technologies

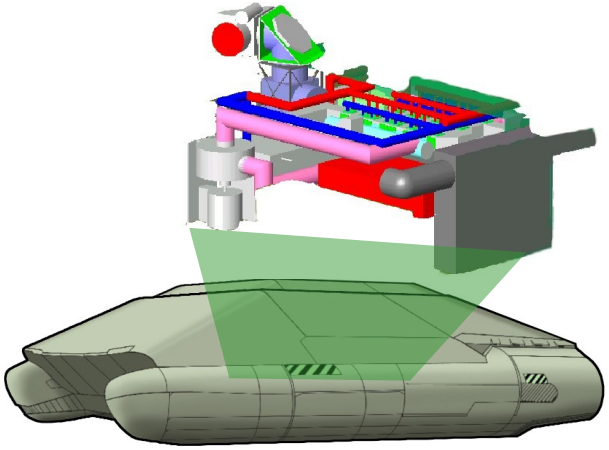
Effects at the Speed of Light

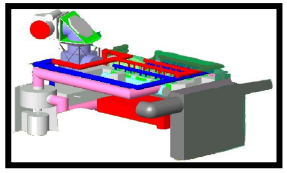
Lethality – Directed Energy

Lethality

Solid State Laser Weapon

- SSL Weapon System Demonstrator for FCS





High Power Microwave (HPM) Enabling Technology

- High Power Electronics
- Antenna Technology

Solid State Laser (SSL)

- 25 kW/100 kW SSL Lab Demo
- SSL Weapon System Components
- 400 kW SSL Lab Demo (FY12)

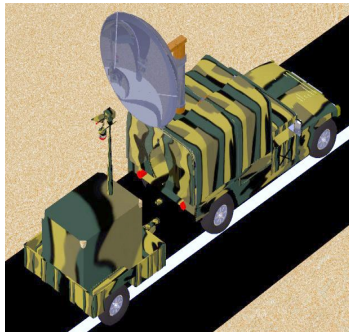
HEL/Space Concepts

- Novel DEW Designs
- Space Control Concepts

Advanced Laser Technology

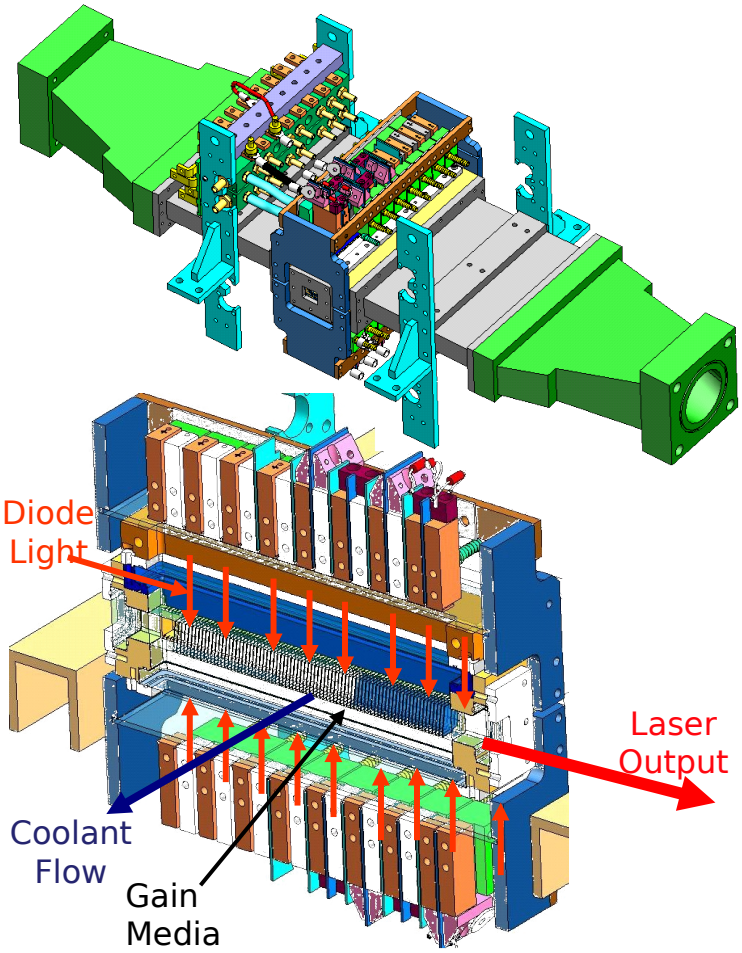
- Novel Materials
- Beam Combining
- New Laser Configurations

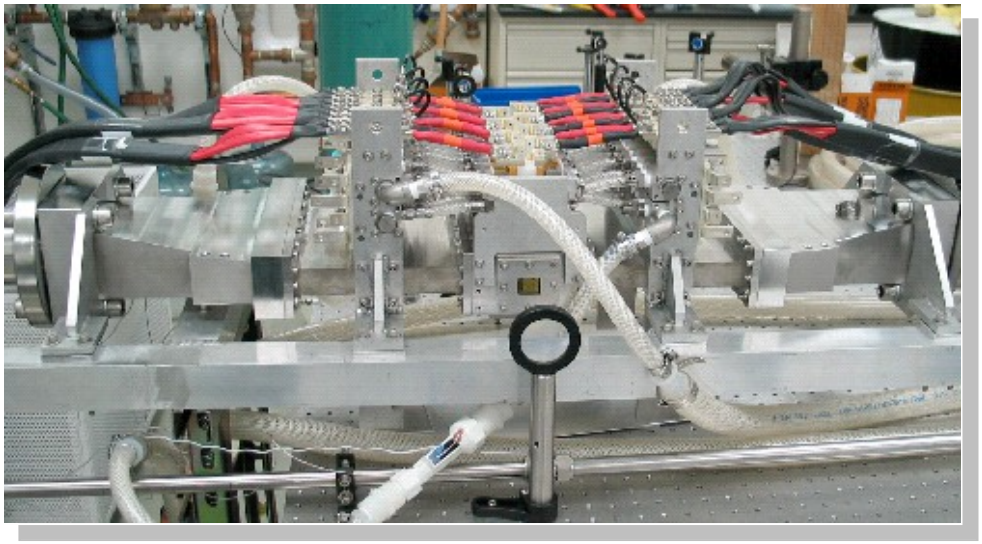
Ground-based Mobile Electronic Attack



Rheostatic Pulsed Energy Weapon System

Liquid Laser





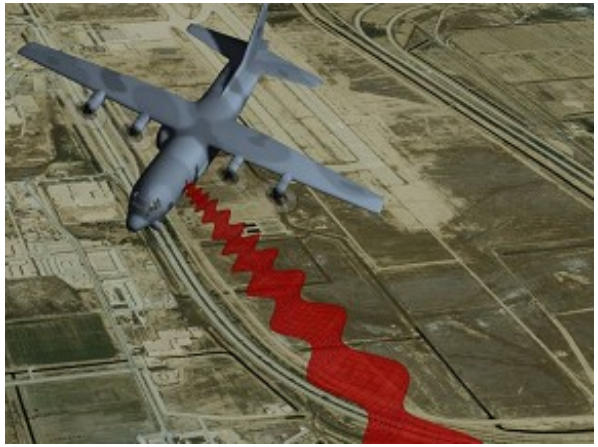
- ***Novel Design That Combines the Energy Density of a Solid State Laser with the Improved Thermal Management Qualities of a Liquid Laser***
- ***System Goals: 150 kW Laser Output, 5 kg/kW***
- ***Enables Laser Weapon Systems Integration with Tactical Platforms***

Airborne Active Denial

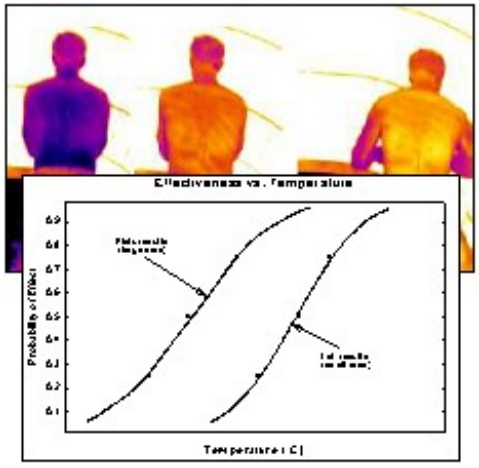
- **Key technologies for airborne non-lethal anti-personnel directed energy weapon**
- **Non-lethal capability from operational altitudes**
  - **Deep magazine**
  - **Speed-of-light**
  - **Line-of-sight**
- **Energy beam heats adversary's skin**
  - **Causes intense pain**
  - **No damage**
  - **Forces adversary to flee**

Ground Based ACTD

Advanced Gyrotrons



Electrical Power



Human Effects Validation

Power and Energy Technologies

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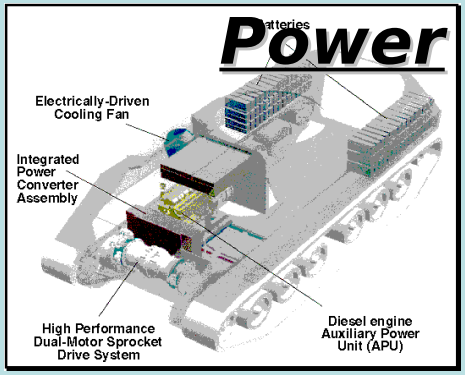
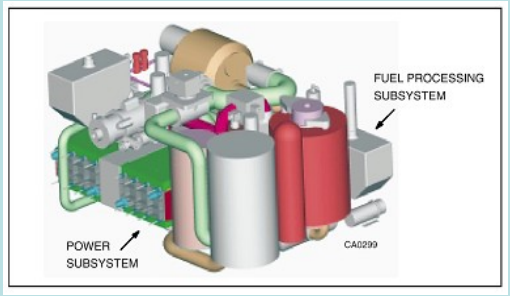
FCS Vehicle Power

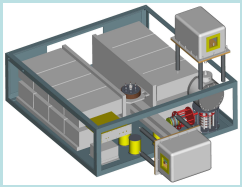

Batteries
Electrically-Driven Cooling Fan
Integrated Power Converter Assembly
High Performance Dual-Motor Sprocket Drive System
Diesel engine Auxiliary Power Unit (APU)

- *All Electric vehicles*
- *Fuel efficiency*
- *Silent mobility*

Hybrid Electric Drive



Diesel Reformer Power



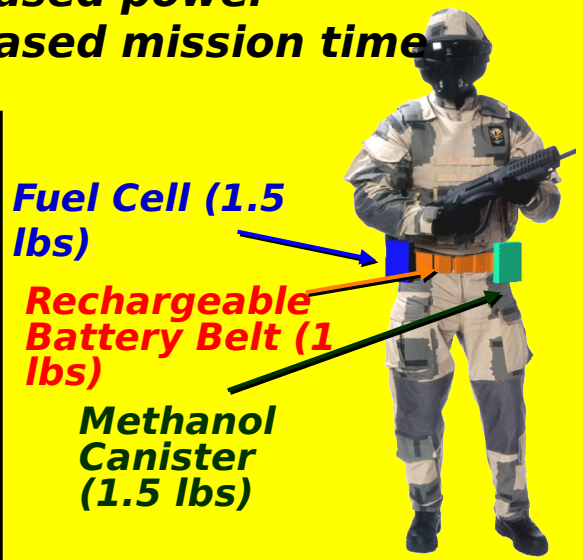
Pulse Power for...
Electric Weapons & Protection

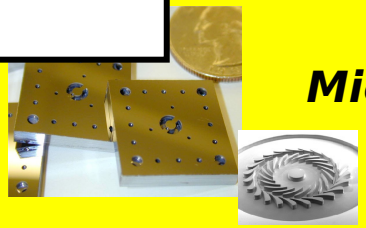
6x Power Density

- *Minimize deployment time*
- *Self Sustainment*
  - *3 days - High optempo*
  - *7 days - Low optempo*
- *New capabilities*
  - *Lethality*
  - *Survivability*

Soldier System Power

- *Reduce weight*
- *Increased power*
- *Increased mission time*

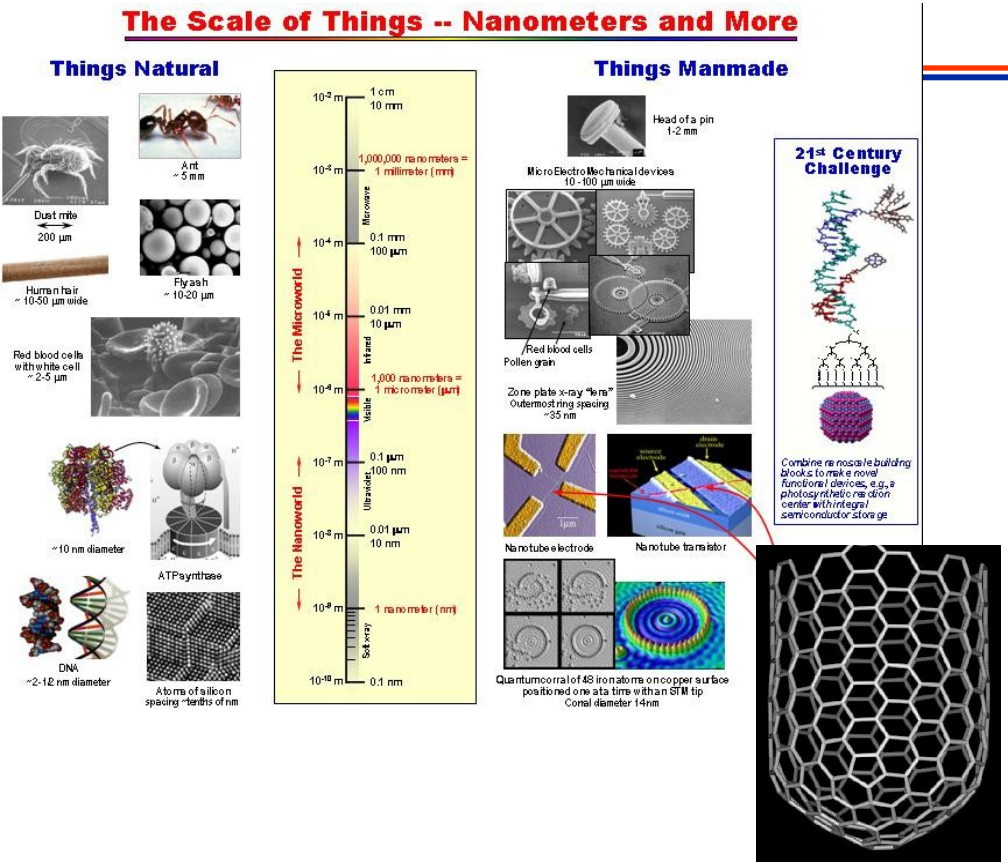




Microturbine/ Microengines

10x Power Density

Single-Wall Carbon Nanotubes



Objective:

SWNT's are the strongest and the best thermal materials known to man.

Robust program will demonstrate technologies for scaleable production, processing and manufacturing of SWNT's

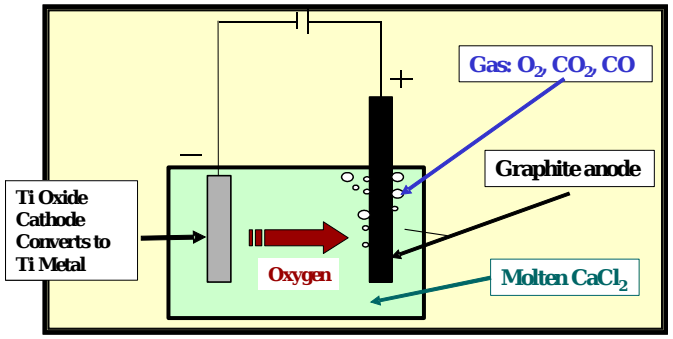
Payoff:

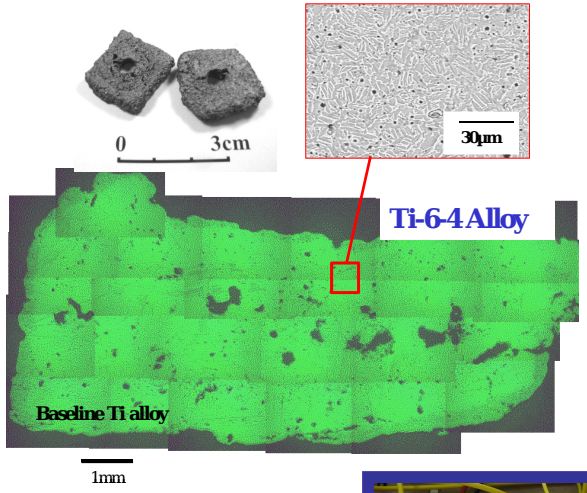
- **Light, Strong power/signal harnesses**
- **Light, high power density motors**
- **Thermal management/heat pipes**
- **Regenerable CO_2 scrrubbers**
- **Fuel cells**
- **Photovoltaics/themophotovo**

Single-Wall Carbon Nanotube (SWNT)

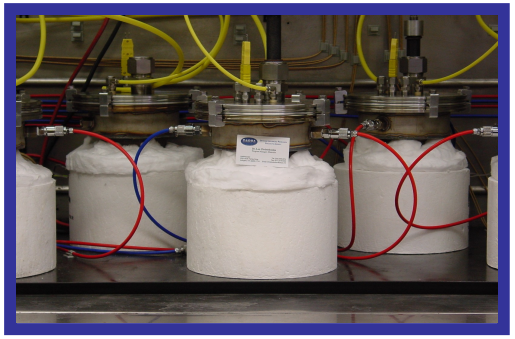
Property	SWNT	Copper	Aluminum
Conductivity	10^4-10^7mho	5x10^5mho	3.8x10^5 mho
Weight	1.4 g/cc	8.9 g/cc	2.7 g/cc
Stability	inert to 500C	corrodes	surface oxide
Thermal Expansion	-2 ppmC^{-1}	-16 ppmC^{-1}	23 ppmC^{-1}
Thermal Conductivity	20-2000 W$m^{-1}K^{-1}$	400 Wm-1K-1	116-235 Wm-1K-1
Tensile Strength	5-20 GPa	0.4-1.5 GPa	0.1-0.6 GPa

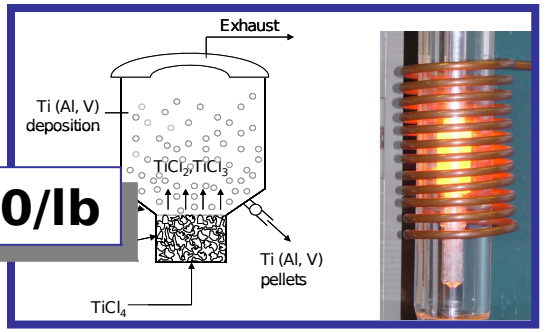
Low Cost Titanium





- **Several competitive routes being examined:**
  - **Electrolytic**
  - **Fluidized Bed**
  - **Na Reduction**
- **Target: < $4/lb**





Cost estimates as low as $1.00-$2.50/lb

DoD Needs One More "Transformation"

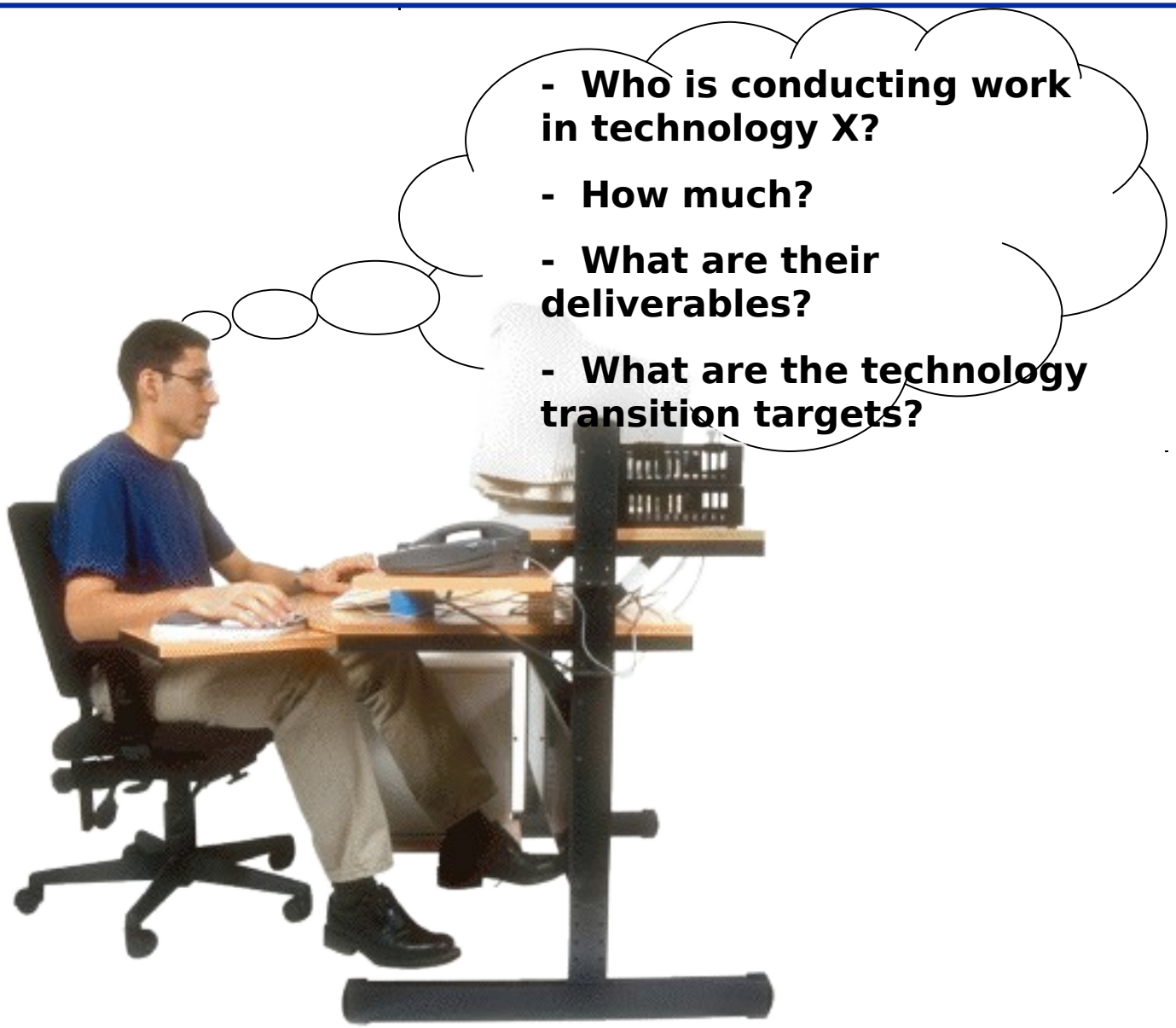
The Information Transformation

Every DoD Researcher, Acquisition Professional, Tester, and Operator should be able to sit down at their Desktop computer and be able to find out:

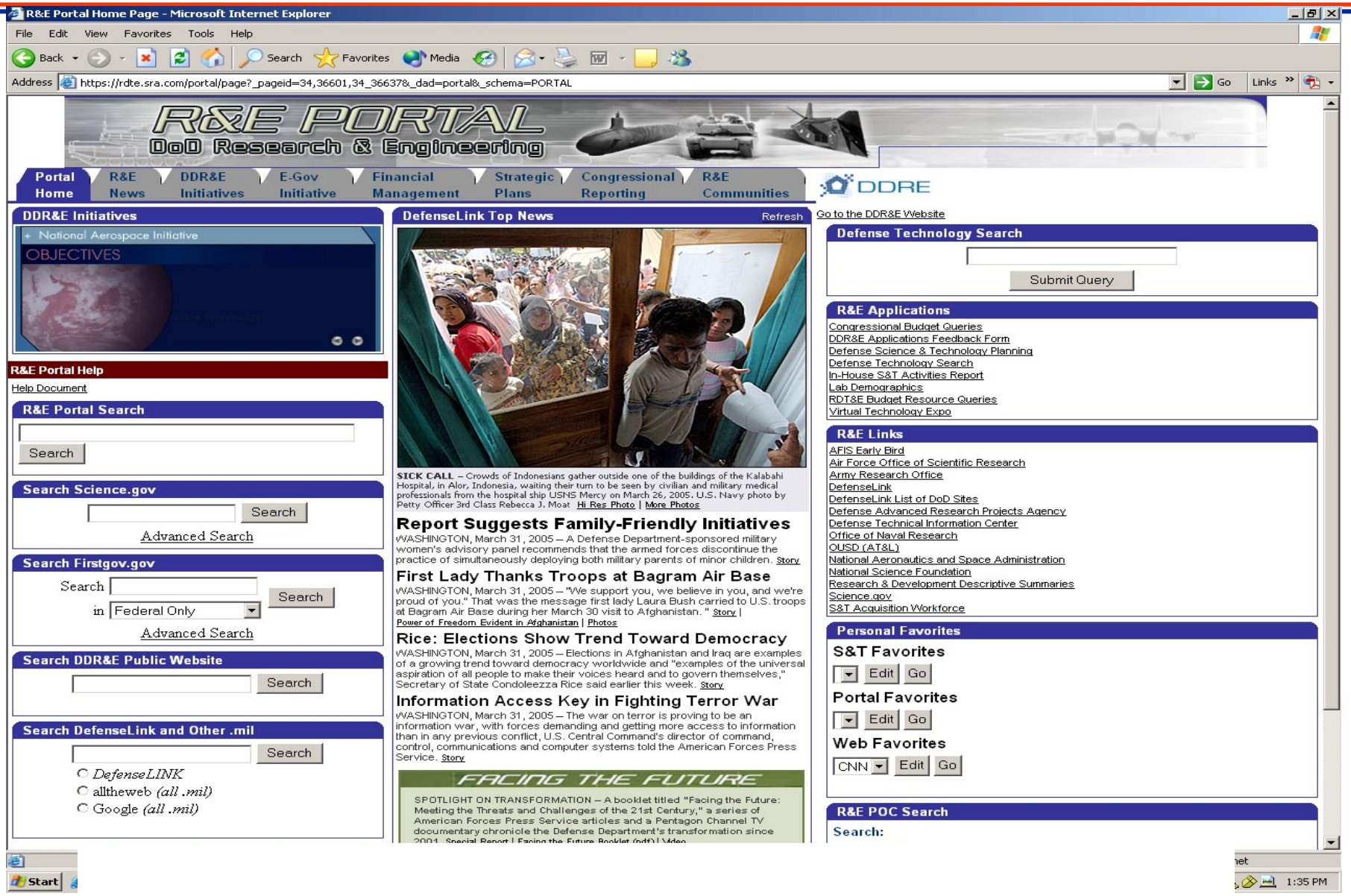
- **What the DoD is doing in R&E**
- **Why we are doing the work**
- **When the work will be done**
- **Who knows more about this**

"Smarter Google" for the RDT&E and Warfighter Community

The Vision


- Who is conducting work in technology X?
- How much?
- What are their deliverables?
- What are the technology transition targets?

R&E Portal

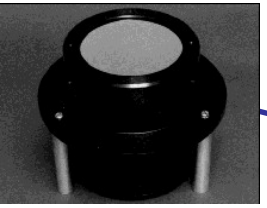

R&E Portal Home Page - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address https://rdte.sra.com/portal/page?_pageid=34,36601,34_36637&_dad=portal&_schema=PORTAL
Go Links
R&E PORTAL
DoD Research & Engineering
Portal Home
R&E News
DDR&E Initiatives
E-Gov Initiative
Financial Management
Strategic Plans
Congressional Reporting
R&E Communities
DDRE
Go to the DDR&E Website
DDR&E Initiatives
National Aerospace Initiative
OBJECTIVES
R&E Portal Help
Help Document
R&E Portal Search
Search
Search Science.gov
Search
Advanced Search
Search Firstgov.gov
Search
in Federal Only
Search
Advanced Search
Search DDR&E Public Website
Search
Search DefenseLink and Other .mil
Search
DefenseLINK
alltheweb (all .mil)
Google (all .mil)
DefenseLink Top News
Refresh
SICK CALL – Crowds of Indonesians gather outside one of the buildings of the Kalabahi Hospital, in Alor, Indonesia, waiting their turn to be seen by civilian and military medical professionals from the hospital ship USNS Mercy on March 26, 2005. U.S. Navy photo by Petty Officer 3rd Class Rebecca J. Moat Hi Res Photo | More Photos
Report Suggests Family-Friendly Initiatives
WASHINGTON, March 31, 2005 – A Defense Department-sponsored military women's advisory panel recommends that the armed forces discontinue the practice of simultaneously deploying both military parents of minor children. Story
First Lady Thanks Troops at Bagram Air Base
WASHINGTON, March 31, 2005 – "We support you, we believe in you, and we're proud of you." That was the message first lady Laura Bush carried to U.S. troops at Bagram Air Base during her March 30 visit to Afghanistan. " Story | Power of Freedom Evident in Afghanistan | Photos
Rice: Elections Show Trend Toward Democracy
WASHINGTON, March 31, 2005 – Elections in Afghanistan and Iraq are examples of a growing trend toward democracy worldwide and "examples of the universal aspiration of all people to make their voices heard and to govern themselves," Secretary of State Condoleezza Rice said earlier this week. Story
Information Access Key in Fighting Terror War
WASHINGTON, March 31, 2005 – The war on terror is proving to be an information war, with forces demanding and getting more access to information than in any previous conflict, U.S. Central Command's director of command, control, communications and computer systems told the American Forces Press Service. Story
FACING THE FUTURE
SPOTLIGHT ON TRANSFORMATION – A booklet titled "Facing the Future: Meeting the Threats and Challenges of the 21st Century," a series of American Forces Press Service articles and a Pentagon Channel TV documentary chronicle the Defense Department's transformation since 2001. Special Report | Facing the Future Booklet (pdf) | Video
Defense Technology Search
Submit Query
R&E Applications
Congressional Budget Queries
DDR&E Applications Feedback Form
Defense Science & Technology Planning
Defense Technology Search
In-House S&T Activities Report
Lab Demographics
RDT&E Budget Resource Queries
Virtual Technology Expo
R&E Links
AFIS Early Bird
Air Force Office of Scientific Research
Army Research Office
DefenseLink
DefenseLink List of DoD Sites
Defense Advanced Research Projects Agency
Defense Technical Information Center
Office of Naval Research
OUSD (AT&L)
National Aeronautics and Space Administration
National Science Foundation
Research & Development Descriptive Summaries
Science.gov
S&T Acquisition Workforce
Personal Favorites
S&T Favorites
Edit Go
Portal Favorites
Edit Go
Web Favorites
CNN Edit Go
R&E POC Search
Search:
Start
1:35 PM

Summary

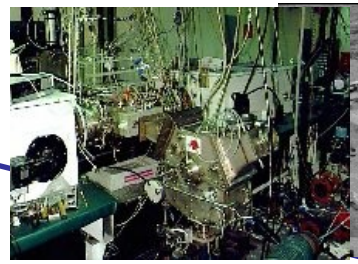
- **Understanding Disruptive Technologies are vital to continued competitive stature**
- **With Increased Knowledge in Rest of World, Pace of Technology, Potential for Technology Surprise Increasing**
- **Need to stay engaged with rest of world to minimize “surprise”**

Backup Slides

S&T Can Take Time for Transition



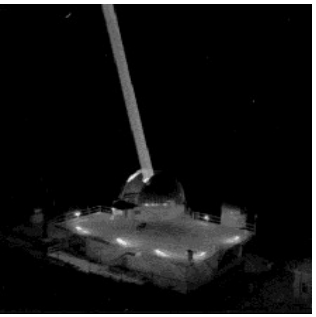
Adaptive Optics



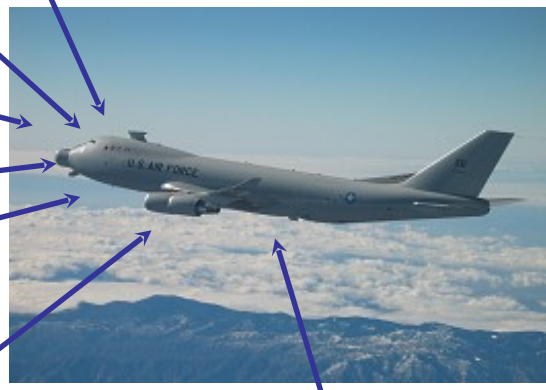
Chemical Oxygen Iodine Laser

Airborne Laser Laboratory

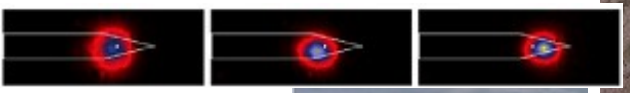
30+ Years of Air Force S&T investments in beam control and high energy lasers have made an ABL Possible



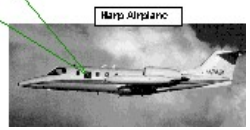
1.5m Telescope



3.5m Telescope



Atmospheric Compensation



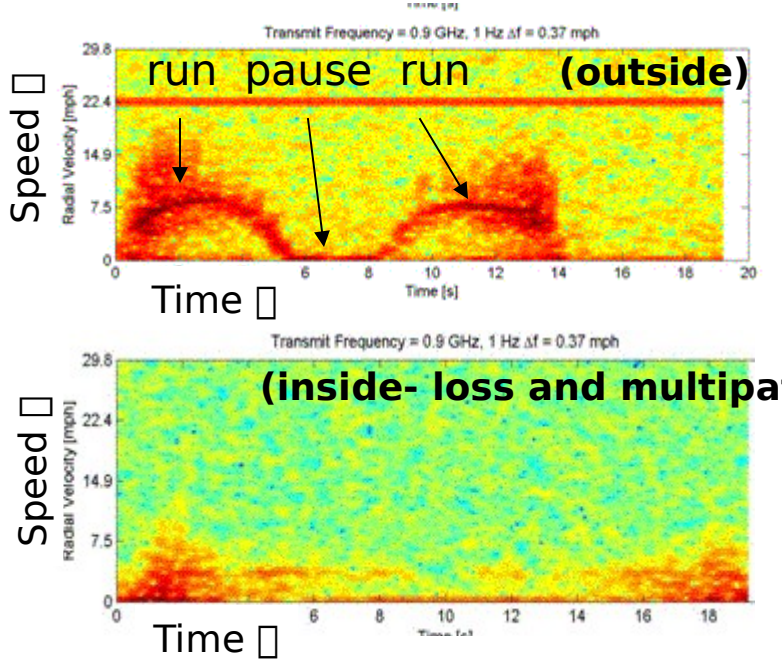
Atmospheric Measurements

Through-the-Wall Imaging for Urban Operations

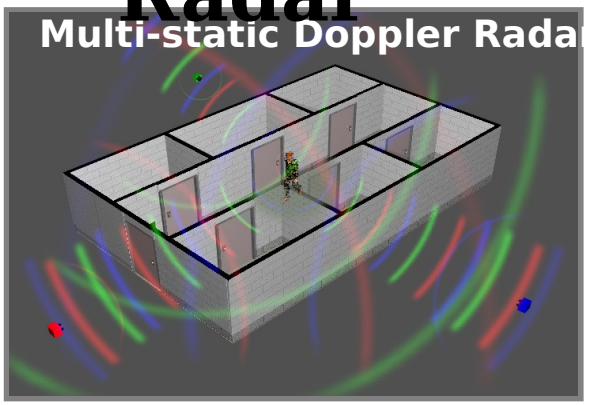
- Strategic collection of threat activity patterns and building layout / door properties using exterior sensors

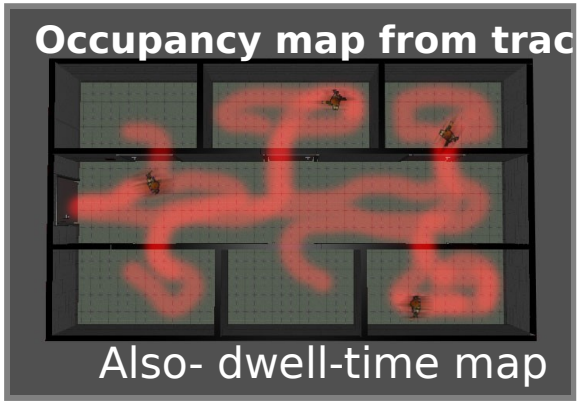
- Tactical detection and localization of adversaries or hostages inside building using exterior sensors

900 MHz Doppler Returns from walker:



MTI Radar

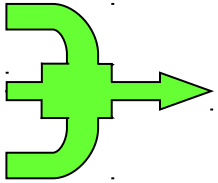




Counter-IED Thrust

- Recently launched (Feb 05) a focused counter-IED research program w/ NRL, University Affiliated Research Centers,etc
- Sustained BASIC Research investment: 10% NRL Base Program; matching ONR extramural funds (to universities, labs, industry, etc.)
- Investment on real-time detection of threat & advanced long-range destruction technologies
- “Feed” USMC CONOPS/Training
- Deliver Counter-IED S&T Roadmap to SECNAV

- Detection at a Distance
- Destruction at a Distance
- Defeat at a Distance



Deterrence

Army S&T Vision—
Pursuing Transformational Capabilities

Current Force

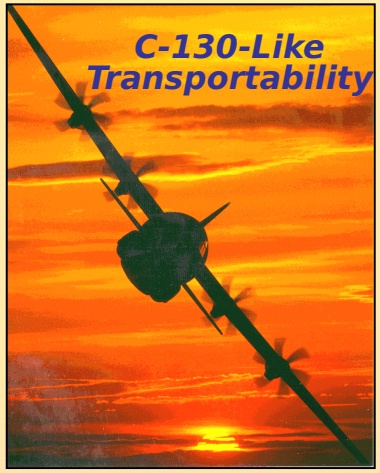
~100 lb. load

70+ tons

< 10 mph

From Platforms to System of Systems

Enabling the Future Force



Enhancing the Current Force

Speed, Reach, and Precision

Future Force

< 40 lb. load

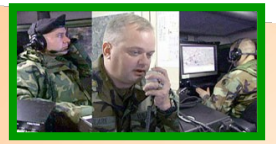
Fully networked

< 20 tons

> 40 mph

Disruptive Technologies

Through Wall Sensing

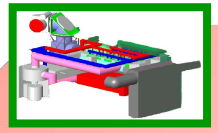


Network Mining

Flexible Displays

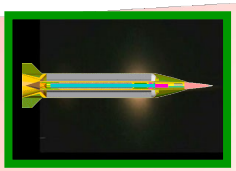
ICB Institute for Collaborative Biotechnologies

Net Centricity

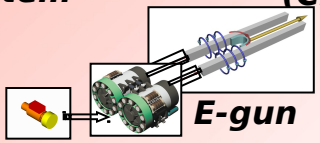


100kW Lab Laser Demo

Non-Line of Sight launch System



Compact Kinetic Energy Missile (CKEM)



E-gun

HPM

Lethality

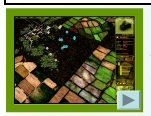
FFW

Autonomy

Active Protection

Institute for Soldier Nanotechnologies

Survivability



Full Spectrum Command

ict

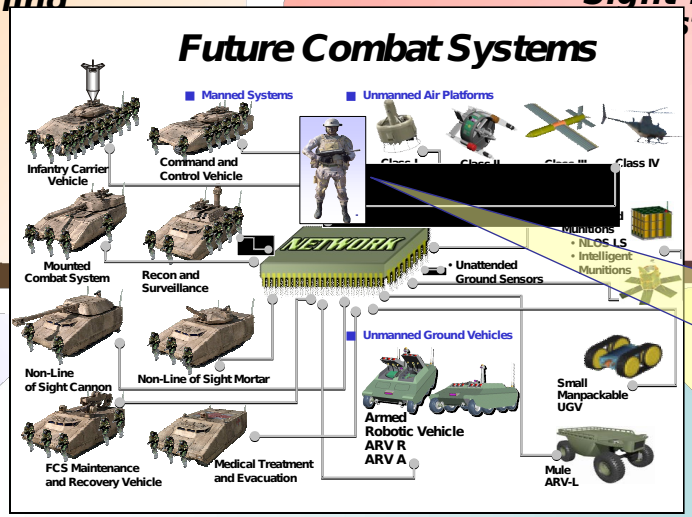
Training

Flatworld

Virtual Dilemma

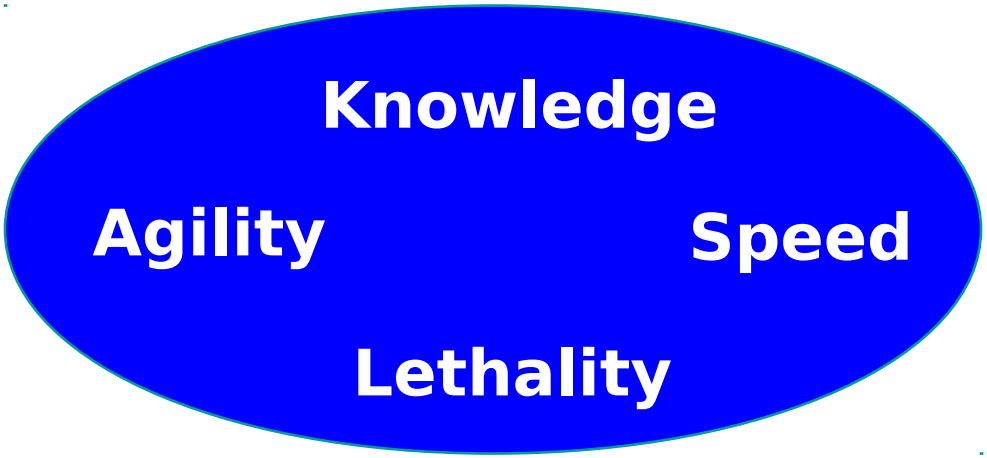
Swarming

Robotics



Providing Strategically Responsive Forces with Information Dominance and Paradigm Shifting Lethality & Survivability

Technology and Transformation
Transformational Attributes



- **DDR&E Transformation Technology Initiatives**
  - **National Aerospace Initiative**
  - **Surveillance and Knowledge Systems**
  - **Energy and Power Technologies**

Traditional Systems Tend to be Mature

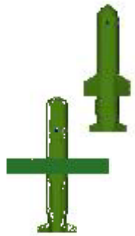
Conventional	Evolving To System	DDR&E Initiative
Air Systems →	Unmanned Systems, Hypersonics →	National Aerospace Initiative
Land Systems →	Future Combat System Objective Force (Army)	Energy & Power Technologies
Sea Systems →	Electric Ship	
	Directed Energy Weapons – Active Denial System – Airborne Relay Mirrors	
	Chem/Bio Defense – Genetic Engineering	
	Ubiquitous Knowledge/Sensing Network Defense	Surveillance & Knowledge Systems

→

Lethality - Missiles

Lethality

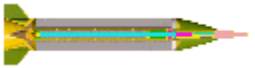
Non Line-of-Sight Launch System



- Extended Range
- -- PAM >50 km/LAM >100 km
- Increased Loiter / LAM-60 min
- Increased Engagement Capability

CKEM

- FCS Spiral
- Lethality Overmatch
- 5 ft / 100 lbs
- On-the-Move Capability

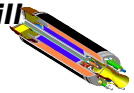


NLOS-LS Air & Ground Variants

- Additional Missile Variants
- Networked Missiles
- Improved Affordability

Guidance & Control

- Precision Targeting
- Increased Kill



Seeker Technology

- Multimode
- Miniaturization
- Automatic Target Acq

Propulsion Technology

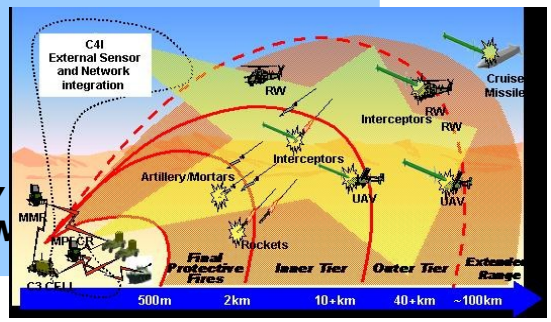
- Increased Velocity
- Longer Range
- Energy Management

Hypersonic Engine

Smaller, Lighter, Cheaper (SLC) Missiles

- Accurate/Maneuverable Urban Weapons
- Lighter/Cheaper Manportable Weapons
- Vehicle, Building & Personnel Targets

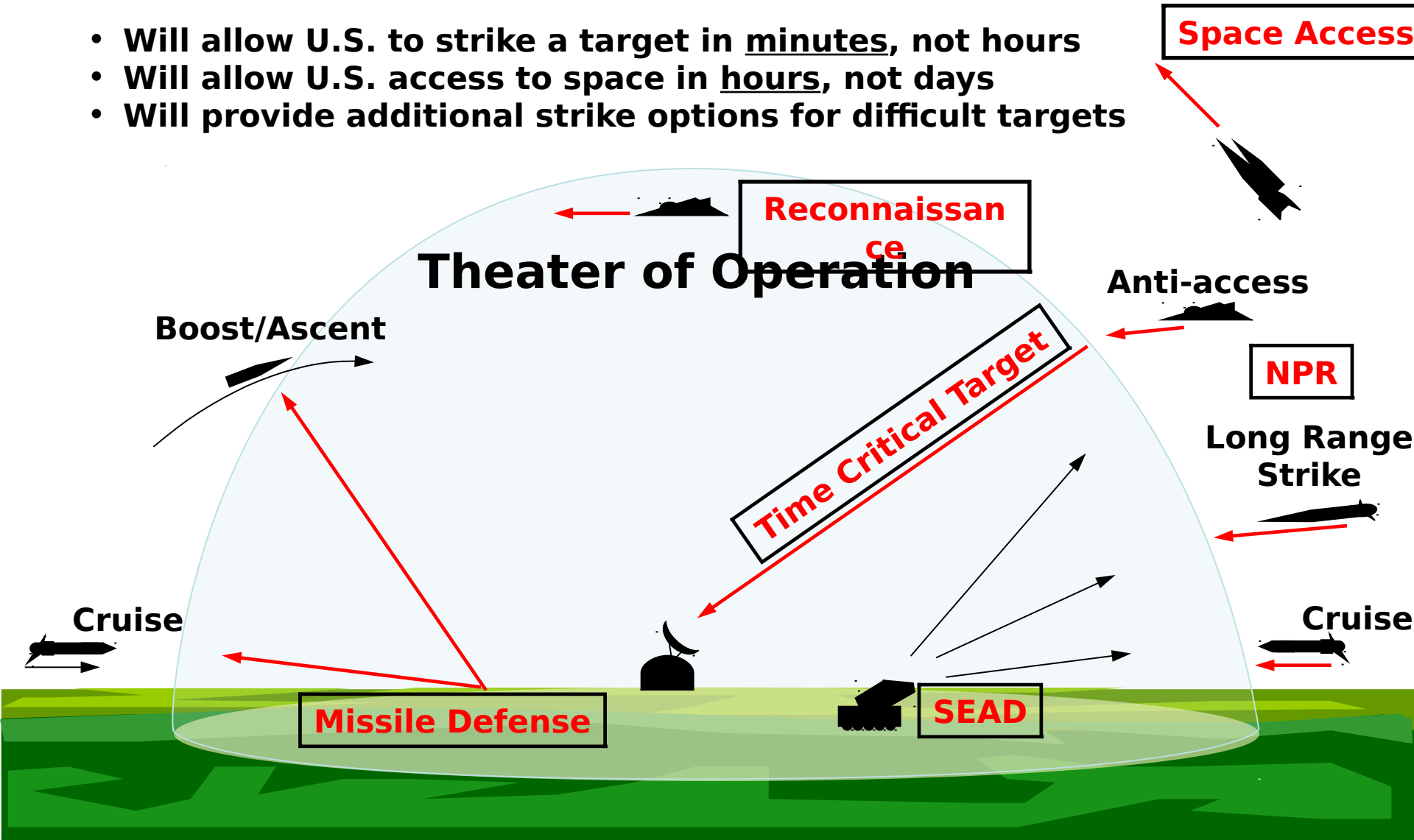
Defense Against Rockets, Artillery Mortars & UAV/CM



Precision Missiles for FCS/Future Force

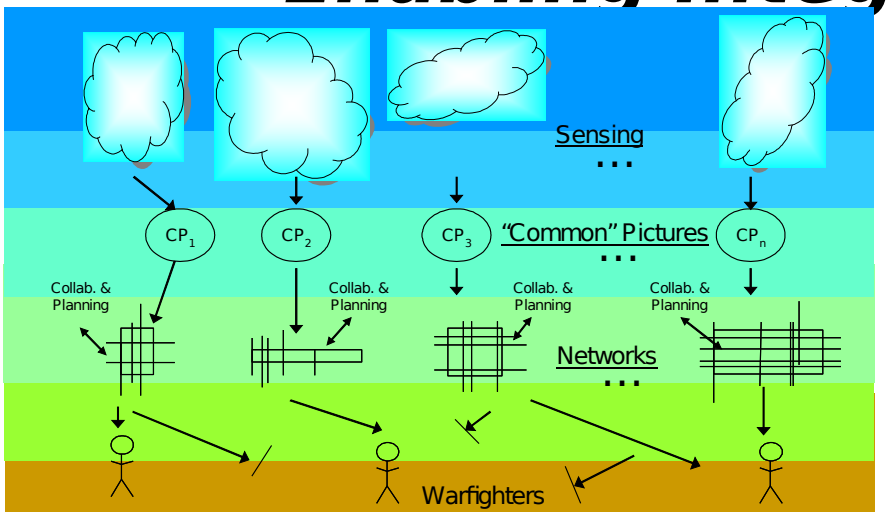
Value of Speed

- Will allow U.S. to strike a target in minutes, not hours
- Will allow U.S. access to space in hours, not days
- Will provide additional strike options for difficult targets

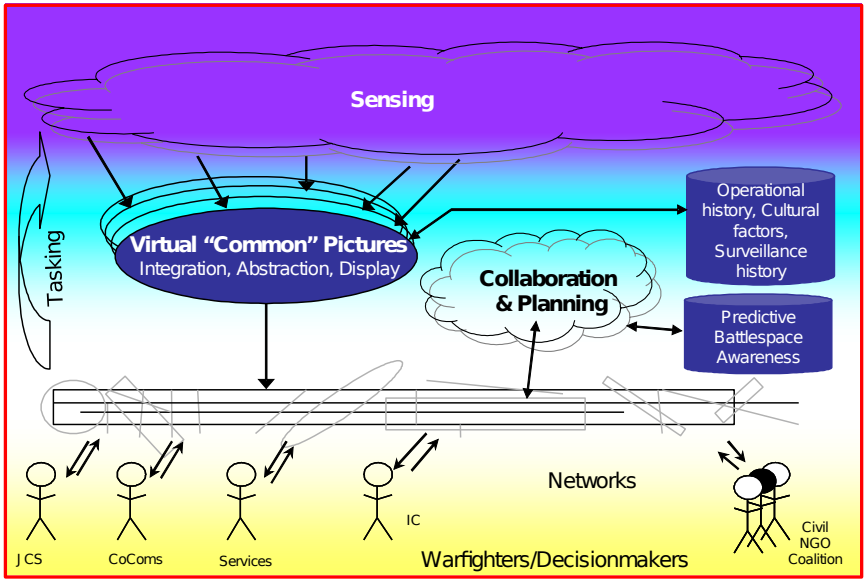


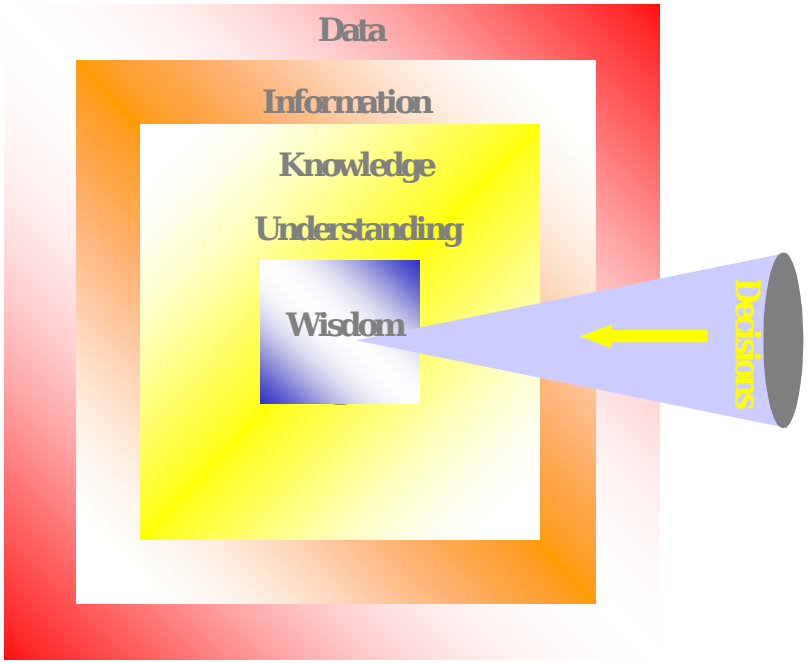
Surveillance and Knowledge Systems

Enabling Integrated C4ISR

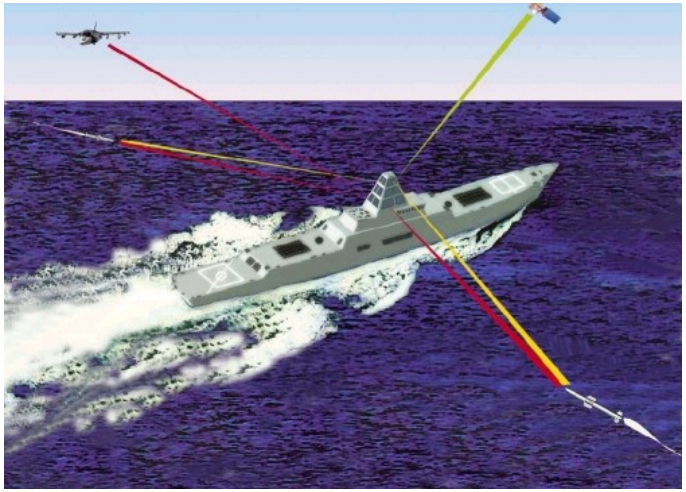


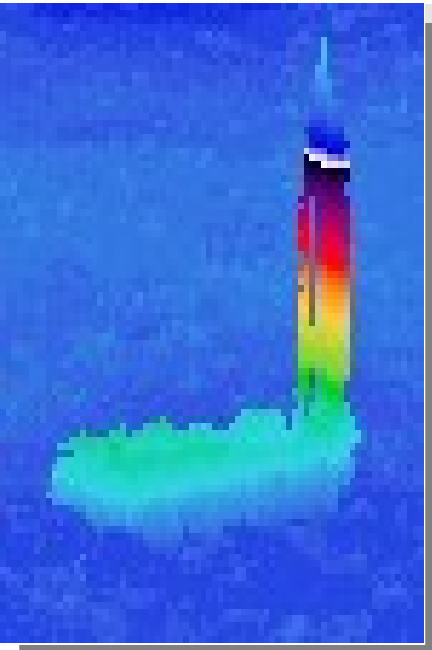
- **Adaptive Networks**
- **Ubiquitous Sensors**
- **Decision Aids**

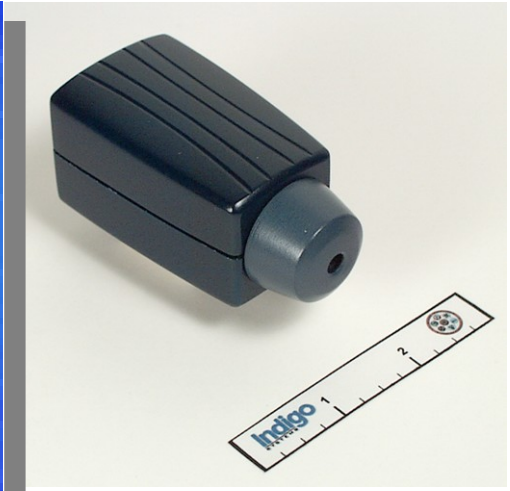




Sensors Are Becoming Part of the System







Some Exciting Initiatives

- ***Interactive remote sensing:*** **Assisted sensing, laser imaging, 3-D sensors**
- ***Sensor webs & fusion:*** **Smart Sensorweb, proliferable microsensors**
- ***Advanced Multifunction RF System (AMRFS):*** **EW, RF, Radar, Comms**

Power Technologies

Pervasive & Enabling

POWER GENERATION

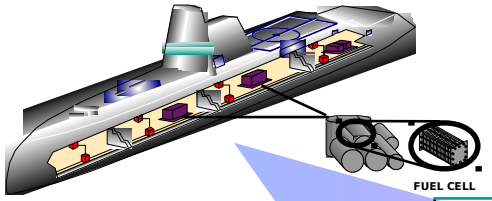
- Fuel Cells & Fuel Reforming
- Novel Power

ENERGY STORAGE

- Batteries
- Capacitors

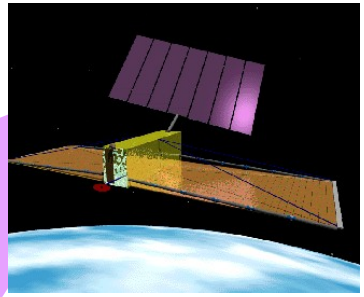
POWER CONTROL AND DISTRIBUTION

- Switching & Conditioning
- Power Transmission & Distribution
- Thermal Management



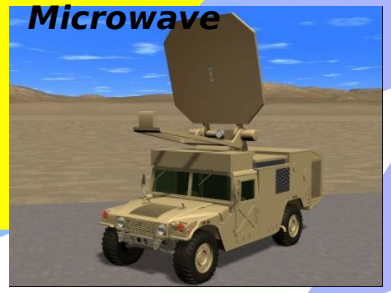
Electric Warship

More Electric Aircraft

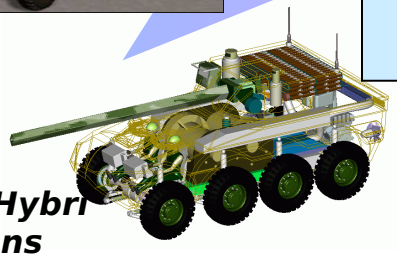


Space Based Radar

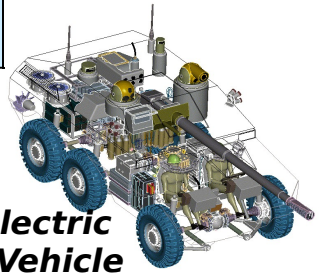
Warrior



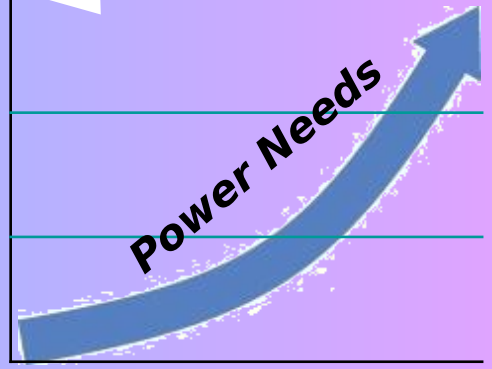
High Power Microwave



Electric/Hybrid Weapons



Hybrid/Electric Combat Vehicle



New Operational Capabilities

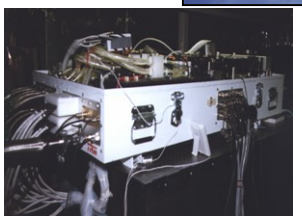
HIGH ENERGY LASERS

Electric High Energy Laser Pulses Can:

- **Cause thermo-mechanical damage**
- **Provide graduated lethality**
- **Offer low cost per kill**

Applications/Missions:

- **Illumination and range finding**
- **Ground and aircraft-based weapo**
- **Air and missile defense**
- **Ship self-defense**



Required Technologies:

- **2X more power efficient diode packages**
- **100X increased diode package reliability**
- **10X higher individual slab/rod/fiber power levels**
- **Beam combining techniques**
- **Improved thermal management (10X lower weight)**
- **Weight efficient power conditioning (pulsed & CW) [10X lower weight]**

Warfighter Payoff

- **Greatly reduced logistic needs (gal's of JP-4 vs $1M missile)**
- **Increased Lethality against:**
  - **-- Boosting TBMs**
  - **-- Maneuvering Threats**
  - **-- Swarm Threats**
  - **-- Threats in close**

High Power Microwave (HPM) Weapons

High Power Radio Frequency/Microwave Pulses that can:

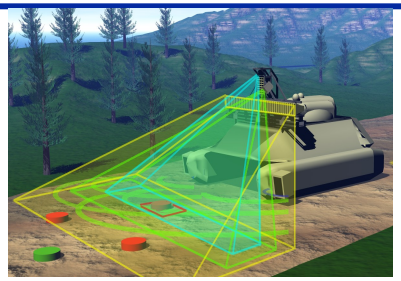
- **Upset and/or Damage Electronics**
- **Produce Non-Lethal Effects on Personnel**
- **Floods Target Area - High P_{hit}**
- **Rheostatic Target Effect (Temporary to Permanent)**

Applications/Missions:

- **Counter Command and Control/Infrastructure, etc**
- **Vehicle/Platform Protection (Counter Mines/ Munitions)**
- **Anti-Personnel/Area Denial/Crowd Control**
- **Air/Missile Defense**

Required Technologies:

- **75% Smaller High Power/Gain Antennas**
- **Effects/Sources Modeling and Simulation**
- **Pulse Power for Mobile Platforms**
  - **2X Operating Voltage for Pulsed Switches**
  - **4X Energy Density for Capacitors**



Counter mines/munitions

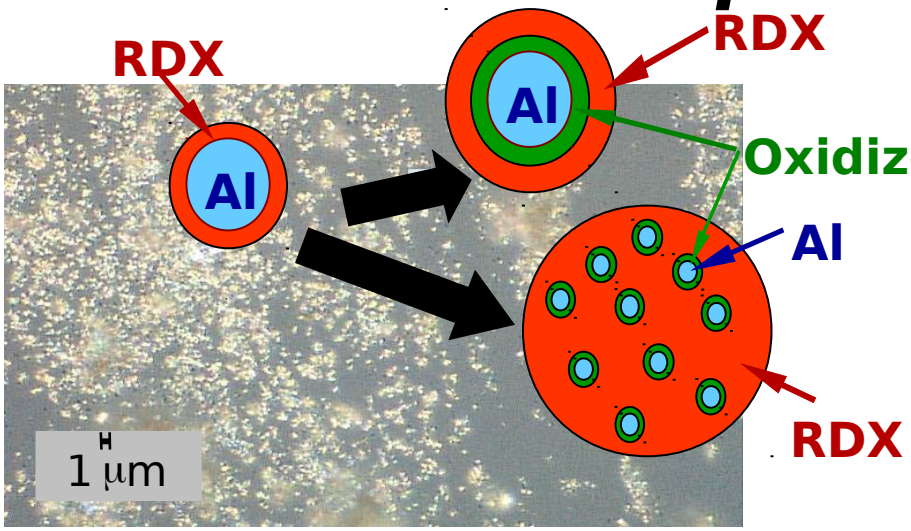
Counter personnel (non-lethal-to-lethal)

Warfighter Payoff

- **40% system weight reduction**
- **90% system volume reduction**
- **Low collateral damage**

Nano Energetics Example

Potential Payoff in Revolutionary Explosives



Nanoscale Aluminum, Coated by RDX

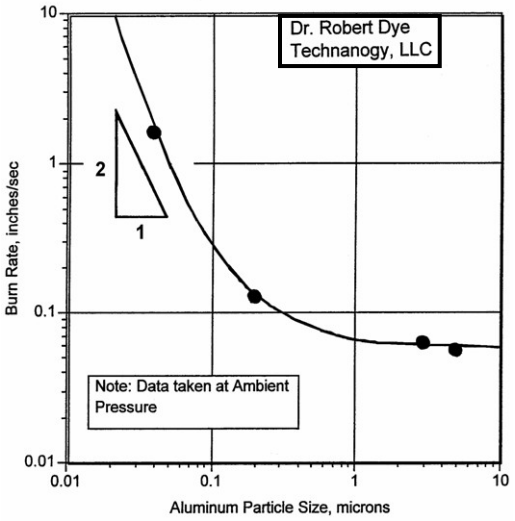
Nano fuel particles coated by oxidizer

- 100x power – increase in energy release rate
- 2x total energy – greater surface and internal volume free energy available
- 10x efficiency – near 100% complete reactions
- 10x safer – lower sensitivity to mechanical initiation
- More compact - no binder

Payoff to the Warfighter

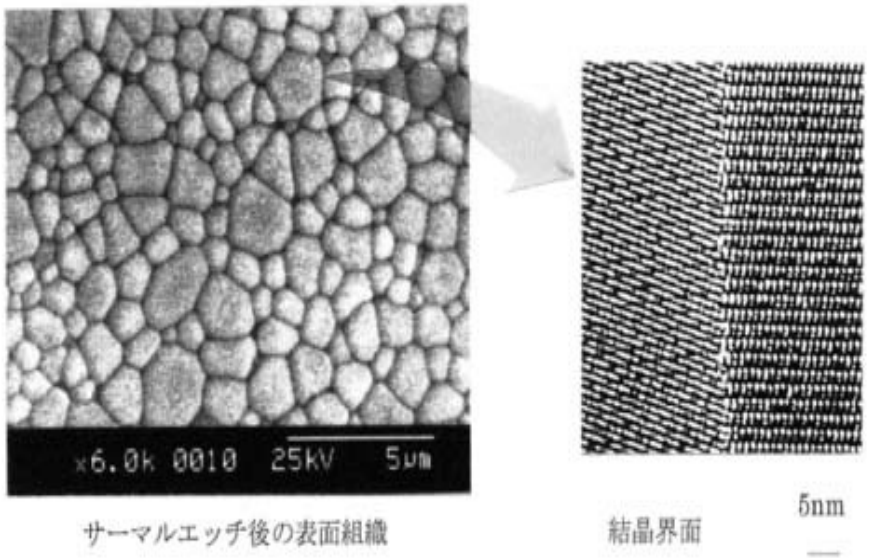
- Smaller, safer munitions
- More kills per event
- Decreased logistics tail
- Enables small, weaponized UAVs

Burn Rate vs. Particle Size



Foreign Example

Nanocrystalline / Nanostructured materials



UNCLASSIFIED

Developed by Konoshima Chemical Co

PLM - higher strength & toughness; Larger sizes; Currently 20% less expensive

Technology can be applied to :

- **Transparent armor**
- **Electromagnetic windows**
- **IR dome materials**
- **Sensor windows**
- **X-ray scintillator materials**

- **Japanese novel patented process to produce YAG nanoparticles**

reaction

- **No pressure required, low temp.**
- **100 nm average diameter**
- **Largely homogeneous**

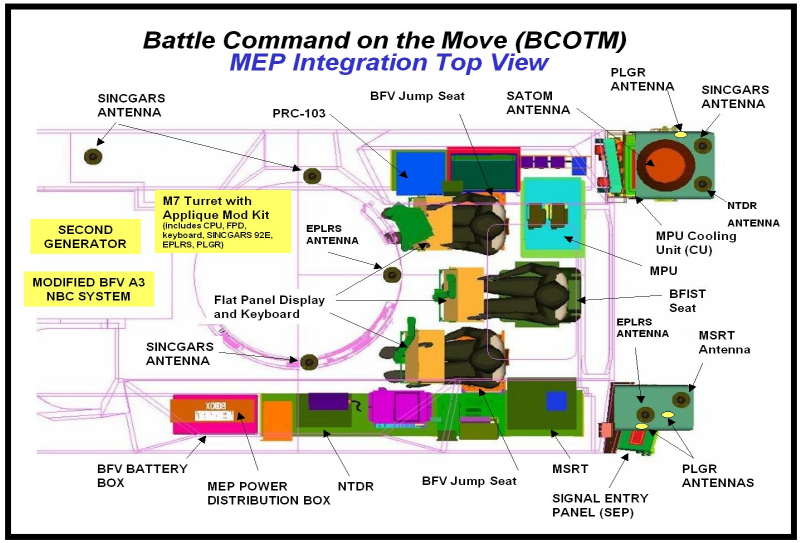
The Future

- **Office of the Director, Defense Research and Engineering asked to study Disruptive Technologies**
  - **Will impact Quadrennial Defense Review formulation**
  - **Probable FY06 start-up initiative**
- **Disruptive Technologies are uncertain**
  - **Final use may not be predictable**
  - **Need to “seed” lots of efforts**
- **Seeking help looking to the future**

Disruptive Technology Example: National Aerospace Initiative

Disruptive Technology Example: Surveillance & Knowledge Systems

Example of Impact in OIF



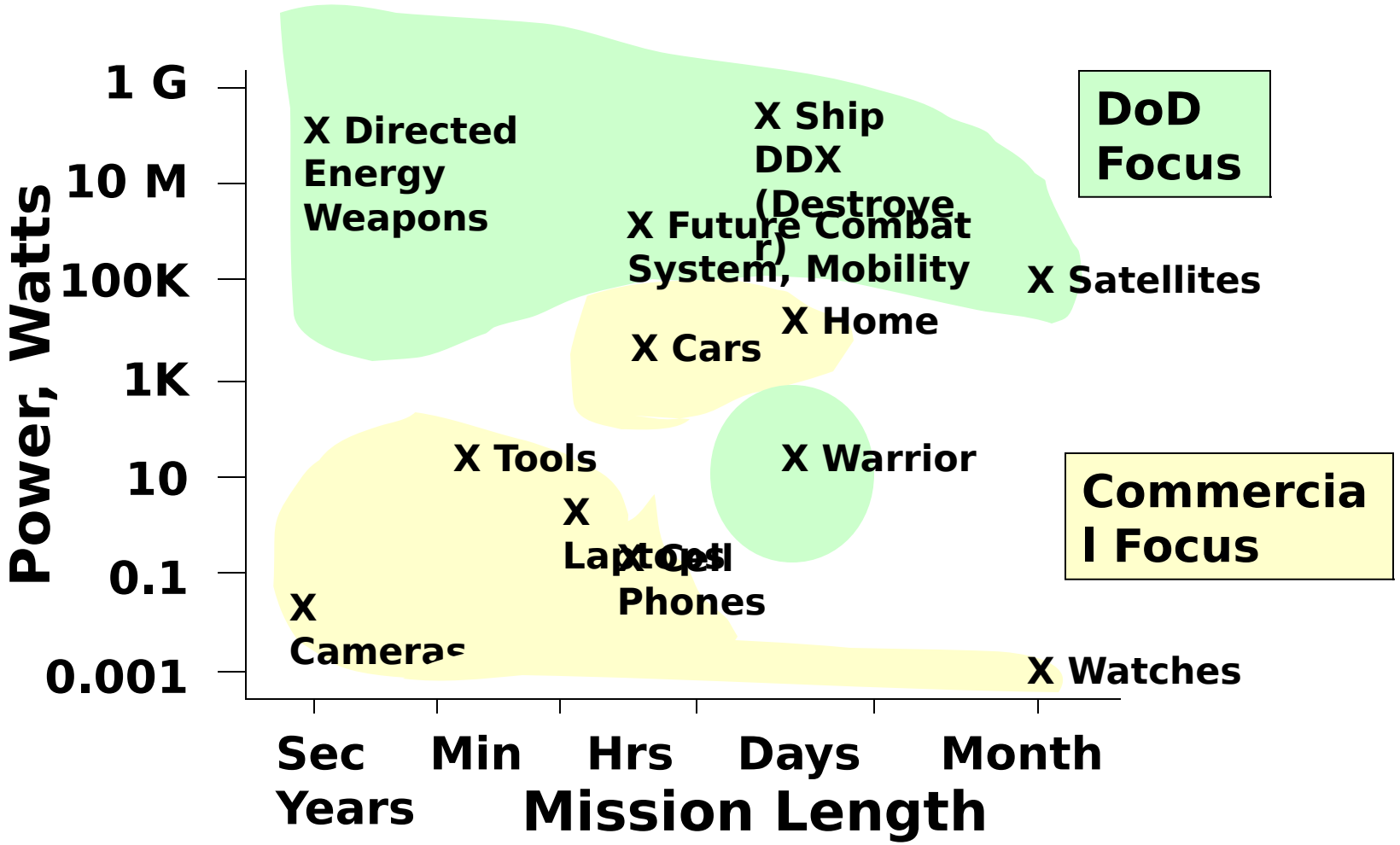
Battle Command on the Move (BCOTM)

In support of PM-Platforms and PM-Bradley, CERDEC designed and developed the Mission Equipment Package (MEP) installation for the BCOTM platform for the 4th ID. The installation integrated the BFA Computer Systems (AFATDS, AMDWS, FBCB2, MCS, ASAS) into a C2 system that provides near real-time battlefield information focused on intelligence, effects and maneuver. Five M7 Bradley vehicles were modified and delivered to the 4th ID within 40 days of project initiation. They are currently deployed for use in OIF, providing the battlefield commander the unique capability of maintaining situational awareness and effectively executing battle command tasks while on-the-move and not tethered to his Command Post.

Freeing the Commander from the Fixed Command Post

Disruptive Technology Example: Energy & Power Technologies

Energy and Power Technologies

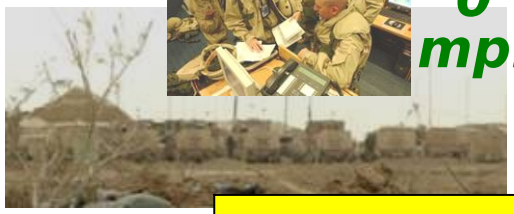


The Objective Force Army

Today

~100 lb. load

70+ tons



0 mph

From Platforms to System of Systems

C-130-Like Transportability

Future Force

< 40 lb. effective load

Fully networked

< 20 tons

> 40 mph

Accelerating Transformational Capabilities